The Engineer

LONDON, FRIDAY, DECEMBER 5, 1941

PUBLIC NOTICES

THE SOUTH STAFFORDSHIRE WATERWORKS COMPANY

RIVER BLITHE SCHEME

The Company Proposes to lay about 6 miles of 33in. diameter Bitumen-lined and Sheathed Steel Main.

Contractors experienced in main laying who wish to submit Tenders are invited to apply for copies of the conditions of contract, specification, schedule of quantities, &c., which will shortly be ready for issue.

Applications should be accompanied by a deposit of Two Guineas, which will be returned on receipt of a bona-fide Tender.

FRED. J. DIXON, M. Inst. C.E.,
Engineer-in-Chief.

50, Sheepcote Street,
Birmingham, 15.
24th November, 1941. 7991

THE HONG KONG GOVERNMENT PUBLIC WORKS DEPARTMENT

APPOINTMENT OF ENGINEER

Engineer Required by the Hong Kong Government Public Works Department for 3 years, with possible permanency. Salary £545, rising to £950 a year. Free passages. Candidates, age 24-32, must be Corporate Members of the Institution of Civil Engineers or the Institution of Municipal and County Engineers, or have passed Sections A and B of the A.M.I.C.E. examination or hold an engineering degree recognised as granting exemption from these Sections; and have had experience in general municipal engineering.—Write, stating age and full particulars of qualifications and experience, to the MINISTRY OF LABOUR AND NATIONAL SERVICE, Central Register Branch, Queen Anne's Chambers, Tothill Street, S.W.1, quoting E. 352. 7994

CHANGE OF NAME OF CLEGG & MURRAY LIMITED

We Beg to Inform our Numerous customers and friends that, with the sanction of the Companies' Registration Department, the NAME of our COMPANY has been CHANGED to that of AUTO-MALLEABLE (HINGLEY), LIMITED, as from the 12th November, 1941. 8000

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For the benefit of applicants, the Proprietors are prepared to insert brief notices that vacancies are filled, upon receipt of notifications from the Advertisers. These notices (limited to one line) will be free of charge, and co-operation is asked for.

IMPORTANT

Advertisers in Situations Open Column should make themselves acquainted with the terms of

STATUTORY RULES & ORDERS 1940 No. 877

RESTRICTION ON ENGAGEMENT ORDER

CHEMICAL ENGINEER—NORTH MIDLANDS. —MANUFACTURERS have VACANCY on Technical Sales Staff for CHEMICAL ENGINEER. Applicants should be University Graduates and have had wide experience of Chemical Manufacturing and Allied Industries.—Address, stating age, experience and salary required, 7962, The Engineer Office. 7962 A

ENGINEERING MANAGER REQUIRED, with first-class Machine Tool and some foundry experience. Good organiser. Work in Midlands employing 600. Salary £720 per annum, progressive.—Address, P3667, The Engineer Office. P3667 A

JUNIOR RATE FIXER REQUIRED for Electrical Switchgear Manufacturers in the Midlands. Good salary and prospects.—Applications, stating previous experience, to be sent to MINISTRY OF LABOUR & NATIONAL SERVICE, Employment Exchange, Banbury, Oxon. 7957 A

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The Engineer

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SITUATIONS OPEN

LEADING FIRM of ENGINEERS WISH to APPOINT CHIEF DESIGNER for their Hydraulic Dept. Must be intimate with the latest practice in regard to all types and sizes of Hydraulic Presses, Pumps, Control Gear, &c. This is an opening of considerable scope for the right man.—Address, giving age, experience, &c., 7992, The Engineer Office. 7992 A

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LADY TRACER, Quick, Neat, Accurate worker, married, DESIRES SPARE-TIME TRACING at home.—Address, P3690, The Engineer Office. P3690 B

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CLASSIFIED ADVERTISEMENTS CLOSE FOR
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The Engineer

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This Supplement, which deals with the Science and Practice of Metallurgy, both ferrous and non-ferrous, is published free with the last issue of THE ENGINEER each alternate month. Next date, December 26th.

ADVERTISEMENTS.

The Charges for Classified Advertisements are 1/- per line up to one inch—minimum charge, 4/-; those occupying one inch or more at the rate of 12/- per inch. Orders must be accompanied by a remittance. The rates for Displayed Advertisements will be forwarded on application. Classified Advertisements cannot be inserted unless delivered before TWO o'clock on Wednesday afternoon.

Letters relating to the Advertisement and the Publishing Departments of the Paper are to be addressed to the Publisher, all other letters are to be addressed to the Editor of THE ENGINEER.

Postal Address,
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PATENTS

THE PROPRIETORS of the PATENT No. 463,115, for "Improvements in or relating to a Method of and Machine for Treating a Steel Rope," are DESIROUS of ENTERING into ARRANGEMENTS by way of LICENCE and otherwise on reasonable terms for the purpose of EXPLOITING the same and ensuring its full development and practical working in this country.—All communications should be addressed in the first instance to Haseltine, Lake and Co., 28, Southampton Buildings, Chancery Lane, London, W.C.2. 7996 H

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For continuation of Small Advertisements see page 64

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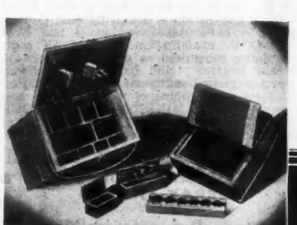

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A Seven-Day Journal

War Transport and a Quick Turn Round

IN the course of an address which he gave before the National Conference of Road Transport Clearing Houses on Thursday, November 27th, Colonel J. J. Llewellin, the Joint Parliamentary Secretary of the Ministry of War Transport, dealt with the important question of war transport and the quick turn round. There were, he said, two essential factors which must ever be borne in mind when handling transport in war. Those were the necessity of ensuring a quick turn round of every means of transport which we possessed and seeing that those same means of transport went on their voyagings and journeyings with all the goods which they could carry and by the shortest routes possible. With regard to road transport, the Ministry was fortunate in being able to build on a well-prepared foundation. Few people, Colonel Llewellin went on to say, outside the Ministry had heard of the Central Transport Council, which was so ably presided over by Mr. Hill. One of its main functions was to eliminate the cross haul and to organise properly the vast amount of traffic which was at the present time being carried on road and rail. On that Committee were representatives of every Government Department which had any substantial interest in the transport of goods. In the war effort all forms of transport must continue to play their part. The advantage of road transport over rail was that its lines of communications were more numerous and were less vulnerable to air attack, while rail transport as against road transport had the advantage of using a home-produced fuel, which did not have to run the gauntlet of the Atlantic crossing. It was worth while to remember that after two years of war our petrol supplies were as good as they were. Our main thanks for this satisfactory position were due to the officers and men who bravely manned our tanker fleets, which, so ably guided and guarded by the Royal Navy, brought each week large supplies of petrol to our shores, and we should also not forget our American friends, who, by their shuttle service, had materially assisted us to maintain our petrol stocks. Road transport, Colonel Llewellin concluded, had not only its part to play during the war, but it had an equally important task to fulfil in the following period of reconstruction.

Increases in Industrial Wages

ON Monday, December 1st, the Ministry of Labour and National Service published in the *Labour Gazette* the results of an inquiry which took place in July last into the earnings of workers in our principal industries. The report, which is based partly on figures supplied by members of the Engineering and Allied Employers' National Federation, and partly on figures from non-federated firms, relates to 56,000 employers representing 6,000,000 workers. The returns show that the average weekly earnings on July 12th were 43·3 per cent. higher than those for October, 1938. It is pointed out by the Ministry that the figures obtained represent fuller employment with longer working hours, an increase in night shifts, and an extension of systems of payment by results, together with changes in the proportions of the men, women, youths and girls who are now employed in the various industries. It is also shown that the average increase in basic wage rates, excluding any overtime, is 18 per cent. In the metal, engineering and shipbuilding industries the figures of July last show that the average weekly earnings of men engaged in these industries were £5 11s. 5d., which represents an increase over the October, 1938, figures of 48·7 per cent. Comparative figures for some of the other sixteen industries which were investigated are as follows:—Mining and quarrying, £4 4s. 7d., or an increase of 40·4 per cent.; textiles, £4 1s. 8d., or 42·5 per cent.; leather, £4 6s. 6d., or 34·5 per cent.; clothing, £4 4s. 11d., 30·5; food, drink and tobacco, £4 7s. 8d., 33; paper and printing, £4 16s. 7d., 15·9; building and contracting, £4 16s. 8d., 46·3; transport, £4 12s. 8d., 29·8; and public utility services, £3 17s. 6d, 23. Further figures given by the Ministry refer to last October, when there was an increase in full-time wages of about £60,000, which was spread over 430,000 workers. During the corresponding period of last year the weekly increase was about £1,900,000 and it concerned about 7,500,000 workers.

New Atlantic Air Record

ON Monday, December 1st, the fastest west-to-east Atlantic flight yet recorded was made by a "Liberator" American-built bomber, which arrived in this country on Monday after a flight of eight hours and twenty-three minutes. The machine was piloted by Captain O. P. Jones, who prior to the war was engaged in civil aviation and was well known to passengers flying by the machines of Imperial Airways, Ltd., and British Overseas Airways. The "Liberator" bomber, we may recall, is a four-engined aircraft of somewhat unorthodox design, having a tricycle undercarriage. This particular type of aircraft has been used extensively for flying pilots who have been engaged in ferrying over new aircraft to Great Britain back to America. The previous fastest west-to-east crossing record was shared by a "Liberator" and a "Boeing Fortress" bomber, both of which machines made the trip in the time of eight hours and forty-three minutes. It may be remembered that in 1937 the flying boat "Cambria," belonging to Imperial Airways, Ltd., flew from Botwood, Newfoundland, to Foynes, in Ireland, in a little over ten and a-half hours.

Wages in the Shipbuilding and Engineering Trades

ARISING out of the claims for increases in wages put forward by the trade unions of the shipbuilding and engineering trades, the National Arbitration Tribunal has already heard the claims of the shipbuilding unions, and those of the engineering unions are to come before it on Monday, December 8th. In support of the campaign the shipyard workers held a conference of shop stewards in Glasgow on Saturday last, which was the first of its kind. At that meeting it was decided to send a national deputation to London as soon as the decision of the Arbitration Court was known to urge the following matters on the Government authorities:—That the question of a basic wage increase of £1 plus 20 per cent. for pieceworkers be considered; that an examination of the bonus system be made to see how far it can be applied to shipyards; that the question of overtime earnings being free from income tax be studied; and that the prices of all foodstuffs should be controlled. The meeting was representative of forty-four shipyards on Merseyside, the Tyne, Clydeside and other shipbuilding areas in Scotland. It was also urged that Mr. A. V. Alexander, the First Lord of the Admiralty, should hold area conferences of shipbuilding shop stewards for the discussion of shipyard problems.

British Plastics in Time of War

IN answer to criticisms of the British plastics industry, coming from unfriendly sources in the United States, probably inspired by Germany, averring that the industry is not fully employed on war work and is seeking to take advantage of the present situation by competing with America in export markets, the British Plastics Federation, Ltd., has issued an official reply. It states that the majority of its members are engaged almost, if not entirely, on vital work for the Government and the Service Departments, particularly the Ministry of Aircraft Production. Quite recently, it is recalled, the Ministry of Labour and National Service decided to apply the Essential Work Order to the moulding powder manufacturing, moulding, manipulating and fabricating branches of the plastics industry. In aircraft production the plastic articles being produced range from transparent material for cockpit and turret screens and landing light covers down to moulded sections for wings and interior panels and structural units for various types of aircraft. The uses to which the plastics industry's raw materials are devoted are moreover strictly supervised by the Plastics Control of the Ministry of Supply. Under a further control exercised by the Limitation of Supplies Order manufacturers can only produce 25 per cent. of their pre-war output over a given period. The British plastics industry, the statement concludes, is concentrating so entirely on the national war effort that the comprehensive export programme initiated by the Plastics Export Group has had to be completely curtailed and placed in "cold storage" until after the war. Fifteen thousand copies of the catalogue and price list intended for distribution overseas to specially appointed joint agents throughout the world now lie idle and unused.

The Loss of H.M.A.S. "Sydney"

IT is with deep regret that we have to record the loss of the Australian cruiser H.M.A.S. "Sydney" with a ship's complement of 42 officers and 603 men, who are believed to be missing. On Tuesday the Admiralty announced that information received from the Australian Naval Board reported that the cruiser had been in action with a heavily armed merchant raider, which she sank by gunfire. No subsequent communication having been received from H.M.A.S. "Sydney," it must be presumed that she has been lost. Extensive search by air and surface units to locate survivors continues. The next-of-kin, to whom the Government and the Naval Board extend their deepest sympathy, were informed on Wednesday, November 26th. For strategic reasons it was not desirable to publish the information earlier than now. The "Sydney" had a most gallant record, and she completed a glorious career in a successful action against the enemy. Recently she has been engaged in seeking out raiders in the southern seas. She was built on the Tyne by Swan, Hunter in 1933 and was completed in the autumn of 1935. Her original name of H.M.S. "Phæton" was changed to "Sydney" when she was transferred to the Australian Navy in September, 1934. She had a displacement of 6830 tons, a length of 555ft., a breadth of 56ft. 8in. and a mean draught of 15ft. 8in. Her armament comprised eight 6in. guns and a similar number of 4in. anti-aircraft guns, besides smaller guns. She was equipped with eight 21in. torpedo tubes in quadruple mountings and carried one aircraft with launching catapult. Her machinery comprised four Parsons geared turbines taking steam from four Admiralty type oil-fired three-drum boilers, giving an output of 72,000 S.H.P., which corresponded to a sea speed of 32·5 knots. The raider, which she sank and from which she received the damage causing her loss, was the Hamburg-Amerika steamer "Steiermark," *alias* "Kormoran," of 9400 tons, which was designed as a merchant raider for wartime use. When so fitted, it is believed that she carried about six 5·9in. guns; and was also probably equipped with under-water torpedo tubes and arrangements for firing torpedoes from her decks. She had a designed sea speed of about 18 knots and carried a complement of some 400 officers and men. Known to the Admiralty for some time as "Raider No. 41," the "Kormoran" left Germany in 1940 and had since operated in many waters and sunk several merchant ships.

Further Canadian Locomotive Experiences

By EDWARD H. LIVESAY

No. X

(*Continued from page 368, November 28th*)

FAST TRAINS.—No. 3, MONTREAL-TORONTO "POOL" SERVICES, C.N. & C.P. RAILWAYS

IT was said in the first article dealing with Canadian express trains that there are only two services in the country bearing comparison with the fast long-distance trains in Britain, such as "The Flying Scotsman" and "Coronation Scot." These are the "Pool" trains running in both directions between Montreal and Toronto. The Canadian and British services are of much the same order; fast "through" trains, with very similar equipment, dining and buffet cars, but no sleepers, the runs being made during the day. Though these trains have many points in common, they differ in that the Canadian examples are much heavier than their British counterparts; their average speed is also lower, but between stops the rate of travel is quite as high. It follows that the locomotive work shows considerable contrast, my experiences with all the trains concerned establishing that the British engines played with their jobs over nine-tenths of the distance, while the Canadian machines worked hard throughout, with no let-up from start to finish. This article is concerned with "Train No. 15," running from Montreal to Toronto. "Nos. 15" and "6," the latter operating in the reverse direction, are the fastest long-distance trains in Canada—conveniently assuming "long-distance" to mean anything over 300 miles; one must work from some given base in dealing with a country as large as the Dominion. The Ottawa trains, dealt with in the second of these articles, only cover a third of this distance.

"Pool" trains are operated jointly by the Canadian National and Canadian Pacific companies, to eliminate the somewhat cut-throat competition indulged in a few years ago for the lucrative traffic between various large Eastern cities, which brought the competitors more kudos than cash. It was found that dividends could not be paid in kudos—some cash at any rate was needed, and hence the sharing, or pooling, of the traffic. In those competitive days "No. 15" covered the 333·8 miles between Montreal and Toronto in half an hour less time than it does at present, which made it the fastest train in the Empire over such a distance, and though it has long since lost that distinction it still ranks high among trains that do not loiter along the road. It was described in a somewhat sketchy way a year or so ago, but another trip in the cab, made recently, under summer weather conditions, enabled me to get fresh and fuller data, particularly of the locomotive work involved in this very heavy service. The "5700" class engines—Fig. 33—employed are especially interesting, and can well stand more being said about them, as they are unique in several respects; they were the first Canadian locomotives to be designed specifically for high speed with heavy loads. Until they appeared, "general-purpose" engines were more popular, and as the same thing is once more the case, in all probability "we shall never look upon their like again."

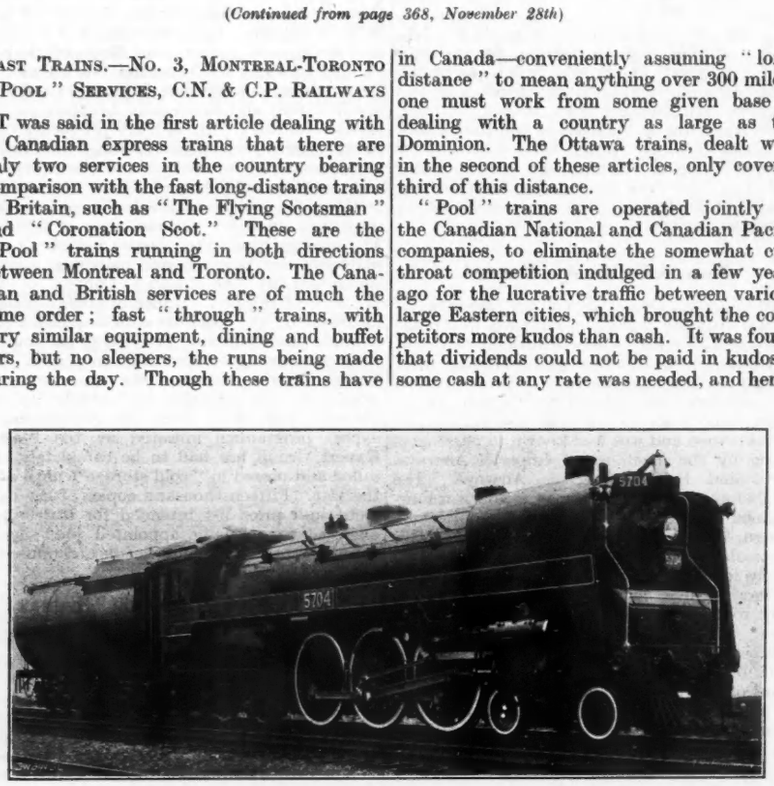


FIG. 33—"5700" CLASS LOCOMOTIVE WITH SIDE PLATES

The "5700" class consists of five engines booster-equipped 4–6–4 "Hudsons," the value of the auxiliary being very apparent in these particular services. Frequent stops in association with high intermediate speed call for rapid acceleration, and without boosters too much time would be wasted in getting away from rest and regaining running speed. Failing boosters, eight-coupled engines would be necessary, entailing higher first and running costs. The booster engine, as fitted to the "5700s," has two cylinders, 8½in. by 12in., driving the rear axle of the trailing truck, on which the weight is 25½ tons. It is geared down 2·57 to 1, giving an additional tractive effort of 10,100 lb., and is cut in and out of gear pneumatically, in the latter case automatically, as the main cylinders are notched up at any speed below 12 m.p.h. The driven wheels are 4ft. diameter and the combined tractive effort of the main and booster engines is 53,400 lb.

The frames and cylinders of the "5700" class engines are cast in one, the latter being 23in. by 28in., with valves 12in. diameter and 9in. travel, actuated by Baker gear. The driving wheels are 6ft. 8in. and carry 84 tons; the factor of adhesion is 4·36 and the tractive effort without the booster 43,300 lb. The boiler dimensions are shown in Fig. 34, and the heating surface totals 4842 square feet, to which the Schmidt superheater contributes 1465 square feet. The fire-box has a brick arch supported on two thermic siphons, and a grate 73·6 square feet in area. The steam pressure is 275 lb. A Franklin "Standard B.K." stoker is fitted, with its engine under the cab. The driving axles have grease-lubricated plain bearings with floating bushes, but all the other axles, both engine and tender, are of the roller type, those on the leading truck of "Nos. 5703–4" being inside. Other features include hand grate shakers, multiple throttle, exhaust steam injector—simpler and lighter than a feed-water heater—air-operated reverse and deflector plates. The Westinghouse pump is fitted above the pilot, in front of the smoke-box, and clasp brakes are used. The weight of the engine is 159 tons.

The tender is of the Vanderbilt tank frame

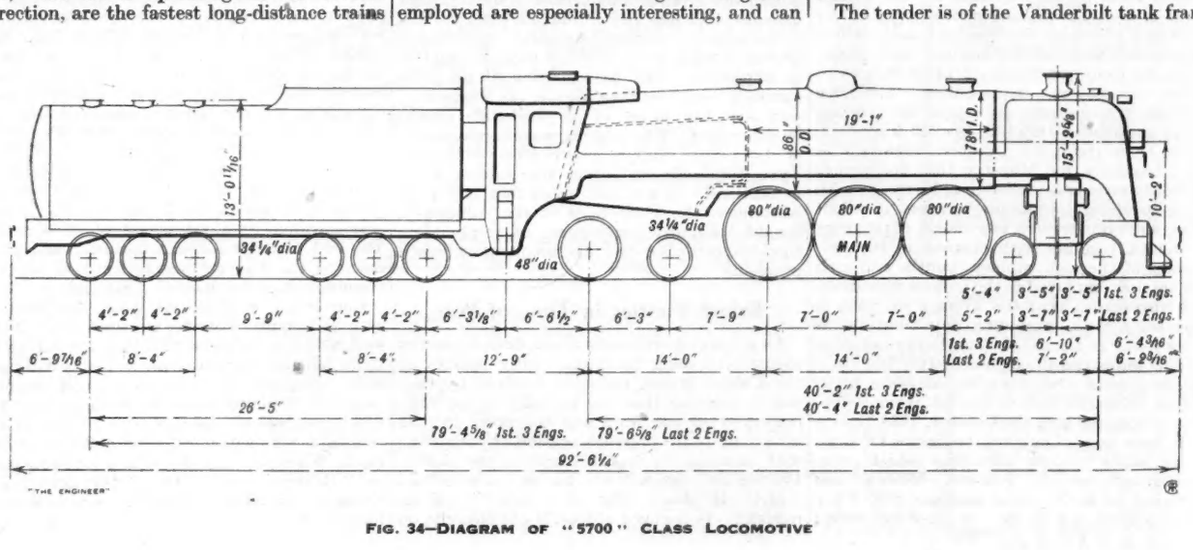


FIG. 34—DIAGRAM OF "5700" CLASS LOCOMOTIVE

type, carrying 14,000 gallons of water, and 18 tons of coal, and has a coal pusher and track sprinkler—to lay the dust when this is excessive. It weighs 130 tons and together with the engine brings the total weight up to 289 tons.

Montreal and Toronto are large cities, the former with a population of over a million, the latter approaching that figure. There are three rail routes between them, two Canadian Pacific and one Canadian National. The C.P. is double track to Glen Tay, 144 miles, where it diverges into separate single lines which come together again near Toronto. The C.N. is double track throughout, and so is better suited for high-speed trains; it is no doubt for this reason that the route was chosen for the fastest "Pool" trains.

"No. 15" is very much "Pool," as it is made up in the C.N. Turcot Yard of both companies' stock, a C.N. engine then hauling—or rather pushing—it round to the C.P. Windsor Station, and taking it through to Toronto, just at first over C.P. metals, then over the C.N. main line into the Union Station of the Queen City, on the shore of Lake Ontario. On the occasion I am describing the engine was "No. 5704," and the train consisted of nine cars weighing roughly 625 tons, considered a light load by the enginemen, Messrs. Barden and Peachey. The weather was extremely hot, upwards of 100 in the shade, and the cab was a roasting inferno when the engine was standing, in spite of every possible aperture being wide open, including both doors. There are four seats on these engines, all of the "stuffed" pattern, two being "drop"; mine was on the left, in the open door, which was thoughtfully chain-guarded. No fear of getting slung out, "Chinook" fashion, this time! Getting away sharp at 3 p.m., and the suburban stops disposed of, the real run began at Montreal West, 3.13, three minutes late. Barden predicted very fast travel later, mentioning a probable figure that made me chuckle inwardly, as speed on this route is restricted to 80 m.p.h., and I imagined this was not likely to be much exceeded. However, I expressed pleasure at the prospect of such meteoric travel, adding that as far as I was concerned the more he "stepped on it" the better I should be pleased. I wonder if I really do look like Verdant Green in the cab. It would almost seem so, judging from speed figures that are sometimes handed to me. A disturbing thought!

At Dorval, a few miles from Montreal West, the train changed over to the C.N. line, and the speed began to rise at once, "No. 5704" soon moving at 75 m.p.h., on three-quarter throttle and 25 per cent. cut-off, to which last figure I am told officially the class is limited. The "full regulator, 15–18 per cent. valve travel" method of running I noticed so often in Britain, particularly on the "Flying Scotsman" and the "Scots," has never been duplicated on any of my runs over here. Possibly the heavier motion may make it undesirable—knocking in boxes and at other places might result. Booster-assisted, the starts had been easy and acceleration rapid. Exhaust pressure, with the controls as stated, was 4–5 lb., about what it should be, so evidently the Ashcroft gauge was registering fact, not fiction. It is not always so conscientious. At speed the riding was good, and there was a long spell of this after St. Annes, 75–80 m.p.h., which got us a little ahead of time at St. Zotique, so "No. 5704" slowed and for awhile took things more calmly. The cab continued hot, in spite of a side wind that blew across it, and was only bearable right in the open door, where I parked myself, refusing to move for anything, except to get at the drinking water cup, which, with ice in and around it, was the most popular accessory within reach. Picking up again near Riviere Beaudette, 80 m.p.h. once more became the gait, along straights well adapted to high speed. I saw Barden take out his watch, so I took out mine, ready for eventualities. Soon came a hail from across the cab: "There you are—mile in 45 seconds, 90 m.p.h.!" "Whoa! Come off the roof—that's only 80!" Then ensued "much argument about it and about," but my explanation probably "came out by the other ear as in it went!" However, the discussion ended quite happily, but this is typical of the way some ultra-high-speed stories get about; in the absence of definite proof it is safest to heed them not. Later, I pondered—had Barden been trying to pull my leg, or did he really think we had been doing 90? Anyhow, we had not.

The Cornwall stop found the train a minute ahead of time, after averaging 63·8 m.p.h. from St. Annes; here water was taken, and a quick start made, followed by a severe incline, 1 in 93, the Hog's Back. The engine accelerated all the way, passing over the crest at about 50 m.p.h. No speed indicator was fitted, so my figures are only estimates, but they are probably under rather than over the mark. Boiler feed became a little troublesome at this point, the injector diaphragm being the cause, preventing easy change over from exhaust to live steam operation, and *vice versâ*. The cab was as sultry as ever. The waves of heat from the back plate could be felt everywhere, in spite of the wind raging through doors and windows; the gale was almost as hot as the radiation! The deck often had to be drenched with water, as everything about the cab was bone dry. Sustained high speed was the feature through and beyond Iroquois, a little over 80 being touched and held awhile. Prescott was passed O.T. at 5.05, with the St. Lawrence blue on the left, and I noticed the air becoming a little cooler. The Brockville stop was made at 5.17, and the crew changed; the 58 miles from Cornwall had been covered in 53 min., 65·7 m.p.h. After the usual servicing by the ground crew and the addition of four cars, bringing the load up to 950 tons, a restart was made at 5.32, with Messrs. Clare and Taylor in the cab, followed by a stop just outside the station for coal, several tons being taken on in three minutes. The countryside began to change somewhat, almost level farmland giving place to rougher terrain, the line passing through rock cuttings, and feeling as if it were on rock foundation. Curvature became more frequent; nevertheless, the speed remained high, the 80 m.p.h. limit being reached, but not exceeded, and braking round bends was sometimes necessary. The shadows lengthened as the evening sun sank low; I sweltered less, enjoying the cooling air. "No. 5704's" behaviour was excellent, and I found nothing to criticise, but Barden had been less appreciative, and had rather damned it with faint praise by saying that it was all right so far as it went, but his regular engine was far better. That old *cliché* again!

"No. 5704" had deflector plates instead of the chimney scoop fitted to "No. 5700," on which my previous run was made, and they were no doubt effective, but I had no means of proving it, as the engine was working hard, the air was hot, so the exhaust was carried well over the roof, without drifting down over the windows or condensing too soon. For the same reason the "Kent" revolving window had little to fight against. Carrying on over a sinuous route to Kingston, the train came to a stand at 6.24, having averaged 54·7 from Brockville, coaling stop included. Immediately outside Kingston a steep gradient begins, three-quarters of a mile at 1 in 98, which cannot be rushed, and on it the 950-ton load called for full throttle; the booster was used for a considerable distance and the steam chest gauge showed 250 lb. and over.

This trip proved too noisy to make conversation easy, and so I may have missed getting some information worth recording. Everything was wide open, and the roar made it necessary to shout in the other man's ear. This gets boring after a time—to both parties. When the whistle chimed in simultaneously it was positively maddening, nearly always resulting in remarks with no bearing whatever on the previous conversation. Fortunately, the atmosphere was becoming more pleasant, the temperature falling to normal as the evening drew on, and I felt less inclination to fly off the handle every time the whistle sounded. "For this relief, much thanks"—and for a mechanical stoker! My sufferings would have been intensified if I had been forced to watch the fireman sweating behind a scoop in that tropic heat, with the roaring white flames reflected on his fevered brow. It would have been painful for both of us; we were spared that, at any rate, thanks to the never-failing feed of the "Franklin B.K." But even so, I was beginning to feel the effect of the heat and long-continued bucketing. This was no diesel-electric power plant, humming smoothly along at 110, gently swaying, controlled from a spotless cab, heat and sound-insulated, with little in it beyond a pair of mahogany armchairs. That was internal combustion—*this* was external, and felt as though quite an appreciable amount was taking place in the cab! My thoughts went back to the "Flying Scotsman" and "Scot" runs, and those beautiful engines, running so easily, almost effortlessly, hour after hour, nothing stressed, nobody strained, with no stops to break the "fine-spun thread," as the panorama of moor, fen and cathedral town slipped away behind. Truly those runs remain in my memory as the perfection of locomotive travel, unequalled anywhere else in the world. This Canadian experience was very different, with its roaring, racking engine, 950-ton load, and frequent halts. And that damned whistle!

Approaching Belleville there was another high-speed stretch, along which 80 m.p.h. was hit and held for several miles, until steam had to be cut for a coaling stop just short of the station, the job occupying five or six minutes, and accounting for the comparatively low average of 50·2 from Kingston. But for this the figure probably would have been over 60. Leaving Belleville with the third and last crew, Messrs. Crozier and Henricks, we began to run into the sunset, on straighter track again, and at the same high speed—or even a little higher. The riding was good, as has been said before, but decidedly not sufficiently so to allow sit-down writing. Some people may be able to do this, on an engine pounding along, lurching and hammering—I am not among the number. I have to assume the vertical and try and stay so until note-taking is over. Port Hope was the next stop, a "flag" one, Lake Ontario coming into the picture, with the setting sun, a ball of red in a turquoise sky, sinking into the silvery waters of the great inland sea. A gentle breeze had begun to blow off the lake, and it got quite chilly in the cab, in contrast to the oven-like temperature prevailing earlier in the day. The flag stop was made at 8.15—to put off a passenger or two—and a little rapid figuring showed the speed from Belleville to have been

63·9, the highest start-to-stop rate of travel since leaving Montreal. I was not surprised—it had felt like it. Away again, to Oshawa, a big manufacturing centre, the General Motors plant being located there, humming and brightly lit, busy on war work. The stop was made at 8.48, lasting a minute only, and we entered on the last lap. Candidly, I was not altogether sorry. I had been six hours in that thunderous cab; the heat had been trying in the early stages, and I was tired and sleepy, wanting nothing so much as to get to Toronto, bath and bed, so the last 33 miles dragged a little. "No. 5704" doubtless felt much the same, as this last lap included the severe Port Union to Scarboro bank, 7 miles of 1 in 100, followed by a similar drop to Danforth, a nice little finale to a strenuous run. It was taken on two-thirds throttle and 40 per cent. cut-off, the steam chest gauge showing 245 lb., and the speed coming down to 20 m.p.h. over the crest. She slipped once, just near the top, nothing to be ashamed of with a 950-ton load, as, of course, the booster was unable to cut in and help, the speed being above its range. Deflector plates were certainly not wanted here; the exhaust sounded angry, harsh, shooting high above the chimney (sorry, stack!) before reluctantly curling back over the train. A very stiff pull. Over the top everybody in the cab relaxed (I believe I used that phrase before, on Shap!), as nothing remained in the way of hard work for engine or crew—it was downgrade and level right into the Union Station, Toronto, reached dead on time, 9.30 p.m. A most interesting and instructive run, certainly the heaviest long-distance express locomotive work I have come in contact with in Canada.

Timetable

Miles.		Time. Working. Arr.	Time. Working. Dep.	Time. Actual. Arr.	Time. Actual. Dep.	Miles between stations.	Average speed, start to stop, m.p.h.	
		p.m.	p.m.	p.m.	p.m.			
	Montreal		3.00		3.00			
2·0	Westmount		3.06		3.07	2·0		
4·7	Montreal W.		3.12		3.15	2·7		
20·8	St. Annes	Pass		3.37	16·1	43·9	Pass	
67·6	Cornwall	4.20	4.24	4.21	4.24	46·8	63·8	Water
113·8	Prescott	Pass	5.05	5.05	46·2	67·6	Pass	
125·6	Brockville	5.20	5.30	5.17	5.32	11·8	59·0	Four cars added, followed by coaling stop
173·0	Kingston	?	6.25	6.24	6.27	47·4	54·7	Water
220·7	Belleville	7.21	7.24	7.24	7.28	47·7	50·2	Preceded by coaling stop
270·8	Port Hope	Flag	8.12	8.15	8.16	50·1	63·9	
300·5	Oshawa	?	8.47	8.48	8.49	29·7	55·7	
333·8	Toronto	9.30		9.30		33·3	48·7	

Montreal West to Toronto, 329·1 miles in 375 min., including eight stops (36 min.); average speed, 52·7 m.p.h. Excluding stops, with no allowance for slowing and regaining speed, 339 min.; average running speed, 55·3 m.p.h. The lower averages to Kingston and Belleville are due to the extra stops for coaling, which affect these two sections.

I have made comparisons with some British expresses in the body of this account; they may be expanded, and put in "deadly parallel," to make them more graphic. The accompanying tables do this. The figures cover runs which I have made with all the four trains at different times. Comparing the British performances with "Train No. 15," the salient impression that remains with me is of an entire absence of any strain with the former, as opposed to a sense of stern, strenuous endeavour with the latter; the respective loads explain this. A rapier in action *versus* a club! The outcome may be the same, but how delicate and graceful the functioning of the one—how rugged and grim the work of the other! The British engines were handled indulgently, as befitted such refined, responsive mechanism; the Canadian engine could be and was thrashed when necessary, and did not complain—it was built to stand it. The tracks are very different—the British is as near perfection as we are ever likely to get. Canadian permanent way is good, too, but—well, it isn't as good as the British. It must have its points, obviously, to stand 300-ton engines and axles loaded with 28 tons pounding over it at 80 m.p.h., with hammer blows far heavier than would ever be permitted in Britain. Steel is as a rule no heavier—I think it is only 100 lb. on the C.N.R. main line—and it is remarkable how they "get away with it"! (They don't always.) Yet I cannot regard even the best American track as incapable of improvement or coming up to British standards. How seldom does one hear of a wreck in Britain due to a broken rail, notwithstanding the vastly greater density of traffic? They are common enough on this side of the Atlantic. A year or two ago the Sperry detector was run over several thousand miles of track, and the discovery of an average of one defective rail to every two miles resulted. This seems simply shocking, and proved that there must have been something decidedly wrong with material or maintenance, or both. The equalising of spring gear is a law of the Medes and Persians in America, but quite unnecessary in Britain, which points in the same direction. Strange things happen to steel in America. A recent wreck was reported to have resulted from a "split rail." I do not know what this means—most likely not what it says. Probably a parallel to a bearing that overheats and seizes—it is "frozen."

Talking over this "No. 15" run with an official at Toronto, he asked if a British engine could have done the job. My reply was a prompt "No—because they aren't built for such heavy work." Subsequent reflection, however, has led to modification of that snap judgment, though the last part of the statement stands, I have little doubt that either a Gresley or Stanier "Pacific" could handle "No. 15," loaded to the 625 tons with which it left Montreal, though I should be dubious about its ability to manage the four-car Brockville addition—950 tons is quite a lot! It might have to ask for the removal of the 80 m.p.h. restriction, as in the absence of the booster it would be slower in getting away from rest and would have to "go some" to make up for it. Granted these concessions, the task should not be beyond it. The fireman also might ask for a thing or two—a rocking grate and mechanical stoker, for instance, and would be justified in doing so, bearing in mind the sort of coal he would have to make the best of. Like Priestley's Johnny Ramsbottom, he would look at it and say: "Call that coal? Ah can't use stoof like that—it's muck! Ah like good stoof!" He would get very little over here. Gilbertson, of "Royal Scot" fame, has strong

Comparison Between Canadian and British Express Engines and Trains

	C.N.R., 4–6–4.	L.N.E.R., 4–6–2.	L.M.S.R., 4–6–2.
Cylinders	(2) 23in. × 28in.	(3) 18½in. × 26in.	(4) 16½in. × 28in.
Driving wheels	6ft. 8in.	6ft. 8in.	6ft. 9in.
Heating surface	4842 sq. ft.	3325 sq. ft.	3663 sq. ft.
Superheater	1465 sq. ft.	749 sq. ft.	856 sq. ft.
Grate area	73·6 sq. ft.	41·25 sq. ft.	50 sq. ft.
Pressure	275 lb.	250 lb.	250 lb.
Adhesion weight—Main	84 tons	66 tons	67 tons
Booster	25¼ tons		
Tractive effort—Main	43,300 lb.	35,455 lb.	40,000 lb.
Booster	10,100 lb.		
Factor of adhesion	4·36	4·18	3·75
Engine weight	159 tons	103 tons	108 tons
Tender weight	130 tons	64 tons	56 tons
Coal	18 tons	8 tons	10 tons
Water	14,000 gals.	5000 gals. (water pick-up)	4000 gals. (water pick-up)

	C.N.R., Train "No. 15," Montreal–Toronto.	L.N.E.R., "Flying Scotsman," London–Edinburgh.	L.M.S.R., "Royal Scot," London–Glasgow.	L.M.S.R., "Coronation Scot," Glasgow–London.
Engine	4–6–4, "No. 5704"	4–6–2, "No. 4491," "Commonwealth of Australia"	4–6–2, "No. 6227," "Duchess of Devonshire"	4–6–2, "No. 6229," "Duchess of Hamilton"
Train weight	625–950 tons	500 tons	500 tons	300 tons
Distance run	329 miles	392 miles	402 miles	402 miles
Longest non-stop run	62·9 miles	392 miles	299 miles	299 miles
Stops	Eight	None	Two	One
Time, inclusive of stops	375 min.	417 min.	419 min.	388 min.
Average speed, inclusive	52·7 m.p.h.	56·4 m.p.h.	57·5 m.p.h.	63·0 m.p.h.
Maximum speed	80 m.p.h.	90 m.p.h.	75 m.p.h.	80 m.p.h.
Coal per mile	80 lb. with 625 tons 114 lb. with 950 tons	45 lb. (?)	45 lb. (?)	40 lb. (?)
Water evaporated	Montreal–Brockville 10,000 gals.; Brockville–Toronto, 24,000 gals.; Total, 34,000 gals.	15,000 gals. (?)	15,000 gals.	?
Crews making run	Three	Two	Two	Two
Max. mileage by one crew	125	200	299	299

The above figures show why the Canadian engine could stand thrashing better than the British. Comparing "No. 5704" with an L.M.S. "Pacific," for instance, their cylinder volumes are nearly equal, the C.N.R. engine's being slightly less, yet the latter has 1179 square feet more heating surface, the superheater is larger by 609 square feet, pressure 25 lb. higher, and it has a 23·6 square foot larger grate, mechanically fed. Starting, even apart from the booster, is made easier by a factor of adhesion of 4·36, against the British engine's 3·75. But a booster would evidently be almost useless to the British engines—on these particular runs—as there are so few intermediate stops; none with the "Flying Scotsman." It would be so much lumber. The key of the whole matter, however, is the mechanical stoker. Without that, the large dimensions would be theoretical advantages only useless in practice.

views on American coal; he will bear me out.

British engines need less outside surveillance than American—they are more self-reliant, automatic. Grease lubrication, for example, calls for attention *en route*; at two points, Brockville and Belleville, "No. 5704" was given the "once over" by ground crews armed with grease guns, hand and pneumatic, whereas the British "Pacifics" ran their 400 miles without any servicing, other than that supplied by their own crews—and very little from them. Incidentally, friction in grease-fed bearings is far greater than with oil, particularly at starting, as they must heat to some extent before lubrication can begin. I have always found big ends too hot to bear the hand on after only a few miles' running. "No. 5704's" grate needed rocking more than once, irons to be used, and the ashpan cleaning twice; the poor-quality coal, and the rate at which it was being burnt, probably accounts for this. *Per contra*, the "Flying Scotsman," minus a rocking grate, hand fired, went right through to Edinburgh, 392 miles, with nothing done to clean the fire, which was by no means over-dirty at the end of the seven hours' run.

The Canadian engine's riding and operation were good, but the British "Pacifics" were better. Twenty-eight-ton axle loads mean stiff springs; "No. 5704" rode hard; the rail reaction of the "Pacifics" was less obtrusive. In any case, a two-cylinder engine cannot compete with a three or four in smoothness of action, still less when running over American permanent way. Does any track in the world approach, say, the L.M.S.R. main line in solidity of construction and perfection of workmanship, material and maintenance? I cannot imagine it, except the L.N.E.R. or G.W.R.! It would be hard to decide which carries off the palm. Look at good British track, with its heavy, creosoted sleepers—quite a recent adoption out here—all mathematically the same size and spacing; its bolted, chair-supported rails, and gravel or rock ballast. Watch it from the cab, peeling away like a grey ribbon underneath; you *know* it is as perfect as human skill can make and keep it—you only hope American track is! At least, that is my reaction. Conviction in the one case, optimism tempered with apprehension in the other. But perhaps I am too fussy—I must watch this.

So much for "No. 5704" and her work with "Train No. 15." I began the run with high expectations, and was not disappointed—except, alas, in one particular. Engineer Barden set his mark too high—we did *not* reach 100 m.p.h.!

A Century of Tunnelling*

No. II

(*Continued from page 371, November 28th*)

TUNNELS CONSTRUCTED WITH THE USE OF SHIELDS

THIS method is adapted to tunnelling in soft and treacherous ground. The shield consists essentially of a short box or tube, covering the periphery of the tunnel and suitably stiffened against collapse from external pressure. Under the cover of this, excavation is carried on at the face. As the excavation proceeds the shield is driven forward by jacks placed round its circumference and thrusting against the completed lining of the tunnel which follows close behind the shield. The back end of the shield is extended by a short length free of any internal structure and within this extension the lining is built. As the shield moves forward a space is left between the lining and the excavated side of the tunnel, which is immediately filled in by grouting with lime or cement. The lining is generally made of cast iron segments bolted together to form a ring. The advantage of this method is that the lining can be built up without the use of centring or shuttering, as would be required with a concrete or brickwork lining, and as each ring is completed it is then ready to take the thrust of the shield jacks without the delay which would arise if one had to wait for the concrete or mortar to set. Cast iron is not an essential accompaniment to shield tunnelling, but its adoption is frequently more convenient and leads to expedition of the work. Other materials are sometimes used and will be referred to later.

The two main advantages of shields are: first, the safety it affords in bad ground; and second, the fact that it reduces or obviates the use of timbering. Heavy timbering is costly and leads to slow progress. On the other hand, a shield is an expensive item of plant. If the tunnel is of a standard size, as in the case of the London tubes, the shield can be taken from job to job (with the exception of the skin, which must be left) and the cost will be distributed. But if it is of large or special size then it becomes so heavy a capital charge on the work that it might be prohibitive on a short tunnel.

Where a shield is not essential from the point of view of safety, its use depends, therefore, on economical considerations. Special cases arise, however, where the shield is unnecessary either on grounds of safety or economy, but where a greater rate of progress may be attained by its use; if speed is the primary consideration, it would then probably be employed.

Though the shield in its present form is a fairly modern device its inception dates back earlier than the beginning of the century under review. It was due to M. I. Brunel, who patented the idea in 1818 and used it in the construction of the first tunnel under the River Thames. In broad principle, however, Brunel's shield and the modern shield differ very little. The shield marked an outstanding advance in tunnel practice, but it was perhaps somewhat ahead of the times, as it was not until 1869 that it was again used, on two tunnels simultaneously, one under the Thames and the other in New York; but in the interim the idea was not lost sight of and a number of patents in connection with it were taken out.

The first shield, designed by Brunel and applied by him to the construction of the Thames tunnel, differed from the later shields in one essential feature, namely, that it was made up of a number of separate units, each of which could be moved forward inpendently of the others. Fig. 6‡ shows the general arrangement of this shield. The next shield, that designed by Greathead for the Tower subway tunnel, a much smaller tunnel, was the prototype of the modern shield. It consisted of a single unit moved forward as a whole, a principle which was adopted universally in all subsequent shields, even of the largest size. Many additions have been made; some of them have been retained, others discarded, but the modern shield is in its essentials the same as Greathead's first shield. Fig. 7 shows a shield of this type.

Types of Shield.—The essential components of a shield are:—

(1) The skin or tube, which is sharpened at the front to form a cutting edge.

(2) The internal structure which stiffens the tube.

(3) The jacks for pushing it forwards. These are invariably hydraulic and are arranged circumferentially round the rim and parallel to the tunnel axis, and they thrust against the finished lining.

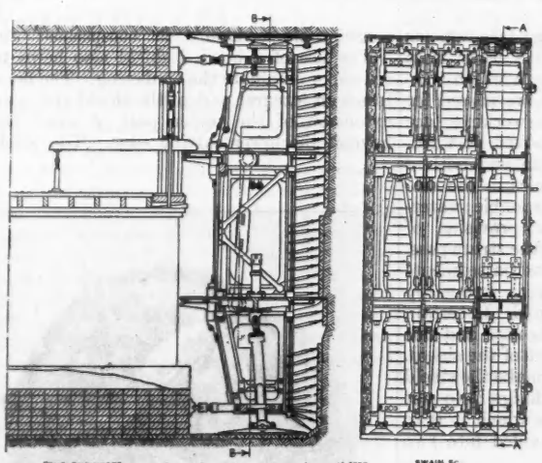


FIG. 6—*Brunel's Shield*

When used in compact ground the front of the shield may be open; but in softer ground a diaphragm plate is used, through which a single door in small shields, or multiple doors or sliding shutters in the large sizes, give access to the working face.

In soft soil the face of the excavation must be supported with poling boards and the timbering may also have to be carried round the perimeter of the tunnel in front of the shield. The poling boards are held by horizontal walings retained by vertical posts or soldiers which are strutted back through the openings of the diaphragm against the completed lining. Alternatively, the timbering is supported by face jacks on the front of the shield, a device now generally adopted for shields for use in soft ground; it was first used on the Waterloo and City Railway in 1895. The shield is the same whether it

* Institution of Mechanical Engineers, Novembe. 21st. The Twenty-eighth Thomas Hawksley Lecturer by W. T. Halcrow.—Abstract.

‡ Reproduced, with permission, from "Tunnel Shields and the Use of Compressed Air in Subaqueous Works," by William Charles Copperthwaite (Constable, London, 1912).

is being used in combination with compressed air or not. Air locks in the shield itself have been tried, with the purpose of maintaining a higher air pressure at the working face than in the remainder of the tunnel. These

FIG. 7—*Greathead Shield*

systems of differential pressures have not been found to be of much benefit and they are cumbersome. They have now gone out of use.

To meet the contingency of a sudden inflow of water at the working face, shields are sometimes provided with a water trap and hanging diaphragm through which suitable hollow cylindrical struts are passed for independent support of the working face when the shield is being moved forward. These struts are fitted at one end with a screw adjustment; at the holes in the diaphragm and water trap reasonable watertightness is secured by the provision of leather sleeves through which the struts pass.

For the erection of the cast iron segments of the lining an erector arm is frequently attached to the back of the shield. In certain soils a mechanical excavator is used and this is embodied as an integral part of the shield.

The modern tendency is to make the shield as simple as possible and to design it to suit the particular class of soil in which it is to be used. Shields may be divided into two main types :—

(*a*) The simple shield, with several variations or additions : (i) with open face, (ii) with diaphragm having single or multiple doors.

(*b*) The rotary shield, which is a shield combined with a rotary excavator.

To either type the mechanical erector can be attached as an integral part.

Fig. 8 shows a diagram of a modern shield of type (*a*) for a 12ft. 3in. diameter tunnel. It is furnished with ten rams and has a total weight of 20 tons. The diameter of the rams is 7in. and the total maximum thrust 385 tons. Fig. 9 shows a rotary shield of type (*b*) for a tunnel of the same size. It has twelve rams and its total weight is 46 tons.

As examples of large shields, the shields for the London tube station tunnels of 21ft. 2½in. internal diameter have a weight of 80 tons and carry twenty-two rams of 7in. in diameter, giving a maximum thrust of 847 tons. The 30ft. 8in. diameter shields used for the Rotherhithe road tunnel (1908) were fitted with forty rams, 9in. in diameter, two erectors and three sets of sliding platforms. The weight was 290 tons, and where hood extension was added it was 342 tons. The total maximum thrust exerted by the rams was 8500 tons.

An interesting modification, introduced by the late Sir Harley H. Dalrymple-Hay, to the face timbering in shield tunnelling under compressed air is the replacement of the poling boards round the cutting edge by tempered clay. A series of pockets are scooped out and refilled with clay, starting from the top and working downwards; these pockets project slightly beyond the circumference of the shield. As the shield is moved forwards the cutting edge becomes embedded in an annular ring of clay, which acts as a seal, preventing the escape of air. This device has been found to effect a considerable economy in compressed air.

The use of a hooded shield also helps to reduce or eliminate the timbering. The hood forms an integral part of the shield and is an extension of the upper part of some 2ft. beyond the lower cutting edge. The whole face is sometimes covered with clay and straw behind the face boards to reduce air leakage. In mixed ground where the top is soft and the bottom in rock or material hard enough to require blasting, a simple hooded shield is used. In some cases where the rock runs level a half-shield or roof shield is used.

There are several types of mechanical excavator which have been specially designed for use with shields. The earliest was the Price excavator employed in 1897 on the Central London Railway. It consists of six radial rams attached to a central shaft on the shield, each carrying a knife spaced at different distances from the centre. The apparatus is revolved about the shaft, when the knives, supplemented by a triangular toothed cutting plate at the centre, break down the face. Each radial arm carries a bucket, which collects the spoil excavated by the knife and tips it into a chute as the arm reaches its uppermost position (Fig. 10).

Another type of excavator is the Carpenter excavator, comprising a horizontal shaft carrying a boring tool and an arm at right angles to it. The arm itself forms the support for a cutting tool which moves automatically to and fro along it as the shaft revolves. The boring tool cuts a central hole while the cutting tool strips the face.

A third type is the Anderson excavator, in which a revolving knife makes a light cut over the whole face at each revolution, which is accompanied by an automatic forward feed.

Lining.—As already indicated, cast iron lining is most commonly adopted in tunnels driven with a shield. The lining consists of

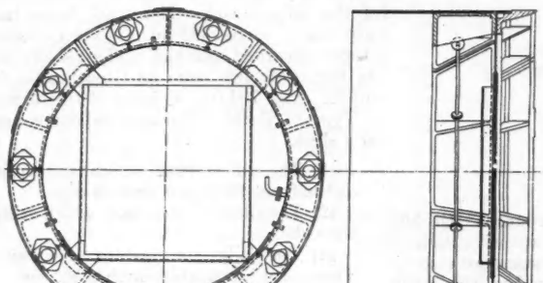


FIG. 8—*Simple Shield for 12ft. 3in. diameter Tunnel*

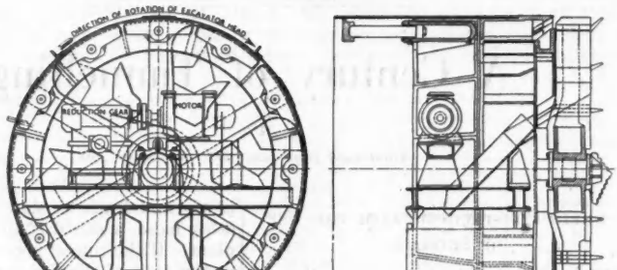


FIG. 9—*Rotary Shield for 12ft. 3in. diameter Tunnel*

FIG. 10—*Shield with Rotary Excavator*

a number of segmental pieces which are bolted together to form a complete ring, generally 18–30in. in width according to the diameter of the tunnel. Each ring is built up, the separate segments being bolted to each other and to the preceding ring.

Joints are made water-tight by caulking with a rust joint or with lead, the former method being, however, inapplicable if water

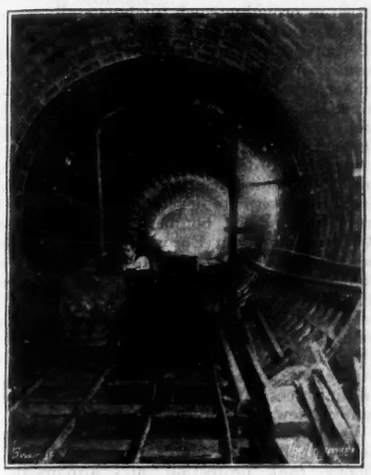


FIG. 11—*Home Office Tunnel Shelters Showing Reinforced Concrete Segment Lining*

is present, unless a preliminary caulking with lead wire is first made. The bolt holes are made tight by a lead washer or by a grummet of hemp soaked in red lead and oil and placed under the washer.

After completing each ring the space left behind it when the shield is moved forward is grouted up with lime or cement grout under pressure. Where large voids occur a method recently adopted for filling the space, which saves cement, is to blow in fine round gravel, passing a ½in. ring, by means of compressed air through grouting holes, and this mass is then grouted up. The advantages of cast iron lining are :—

(1) No shuttering or centring is required.
(2) Each ring is ready, on completion, to take the thrust of the hydraulic jacks without loss of time.

A mechanical erector is generally used to place the heavy cast iron segments in position. It consists essentially of an arm, at the back of the shield, rotating about the centre. The segment is supported by the arm, which is then turned to the required position.

Concrete in the form of keyed pre-cast blocks (Fig. 11) is now sometimes used for lining. These can support the thrust of the jacks and they have been found to lend themselves to a high rate of progress. When pre-cast blocks are used an internal lining of monolithic concrete is, on occasions, subsequently added. A combination of steel joists and concrete was used on the land tunnels of the Mersey tunnel.

Rate of Progress.—In shield tunnelling conditions vary so greatly that it is difficult to give any general figures. Tunnels through London clay, mostly under 13ft. in diameter, have shown an average rate of progress of 85ft. a week with hand excavation and 165ft. a week with mechanical excavation. With larger tunnels and in water-bearing ground the rate is in most cases slower.

The record for tunnelling with a shield and compressed air was established in 1937 on the Detroit sewer tunnel, using a 22ft. diameter shield. The soil was soft clay. The lining was made of pre-cast interlocking concrete blocks, 18in. thick and 30in. wide, and was later supplemented by an internal lining of concrete deposited *in situ*. An average advance of 50ft. a day or, say, 275ft. a week was maintained.

(To be continued)

Science and Government*

AS we come to the end of another year we can see, as yet, no prospect for science of escape from urgent preoccupation with the means of waging war. On the contrary, with the Union of Soviet Russia now locked in a supreme struggle for its own existence and the world's freedom, and with the United States of America rapidly directing its tremendous scientific and technical potential to the support of the same great cause, the diversion of science from its normal uses and objectives has spread right round the world. Yet even this grim necessity has brought with it some measure of compensation, in drawing closer the bonds of friendship, between the men of science in the countries thus united in a common purpose. We in Britain received a tremendous encouragement in the early months of this year from the visit of President Conant and his associates to establish here, in London, an office for the maintenance of regular and intimate co-operation between the war researches of our American colleagues and those which are here in hand. More recently, and in spite of all difficulties of communication, the sense of a common peril and a common determination is bringing us into a new and growing intimacy of collaboration with our colleagues of Soviet Russia. The organisation of the science of the British Empire for war has brought to London already a number of distinguished colleagues from the Overseas Dominions, and we have heard of others who are on the way. It has been a particular pleasure to gather them here, in the house of the Royal Society, and to invite them to regard it as a centre and a rallying point for discussion of the means by which this new and closer collaboration, arising under the stimulus and the necessity of war, may be perpetuated and strengthened for the purposes of peace.

Generous gifts to the Society during the year from sister societies in America have given further welcome evidence of the determination of our colleagues there to come to the help of British science in this time of need. The American Philosophical Society, founded in 1743 by Benjamin Franklin, with this Society as his model, sent us 10,000 dollars "for the aid of science in Britain." They have confirmed our interpretation of their fraternal gift, as betokening a desire to help us to preserve some measure of normal scientific activity in this country during the war, and to keep alive the tradition of a free pursuit of knowledge for the benefit of all men. We have been able to find good use already for a large part of this benefaction, in the maintenance of a number of important researches, which war conditions had threatened to interrupt or to bring to an end. The American Physiological Society similarly sent us 5000 dollars, as a spontaneous contribution, to the support of scientific publication in Britain, mentioning physiology as the subject to which they, as physiologists, desired us to give the first consideration. The Rockefeller Foundation, that truly international benefactor and promoter of natural knowledge, had already asked us to be responsible for the distribution of 12,500 dollars in aid of scientific publication in Britain in these difficult times.

As I have taken occasion earlier to state, gifts such a these, welcome for their own intrinsic value and for the practical uses which we are readily finding for them, are even more welcome on account of the evidence that they bring, of the feeling of comradeship between our American colleagues and ourselves. We can do no less, I think, than assure them of our determination that this closer sense of unity in aims and ideals, with them as with our fellow-citizens of the British Overseas Dominions, shall not be lost, but rather strengthened, when we face together the new problems which the end of the war will bring.

Though the first and imperative call on the science of all free countries is for the means of winning the war to save the freedom without which science cannot in any true sense survive, we cannot put aside the duty of preparing for the part which science must play in rebuilding and maintaining civilisation when peace returns. The Conference recently organised by the British Association on "Science and the World Order" attracted more attention from the Press and the public than is usually given to scientific events and discussions; and it was, indeed, an impressive and significant fact that men of science from a dozen or more different countries, some far distant, should have found it possible now to meet, here in our war-scarred London, and to find the time and the impulse for such debate. We may offer our very sincere congratulations on the success of such an enterprise. Many who took part in these meetings, held at a time when Science finds itself conscript and organised as never before, for the destructive purposes of war, were clearly ready to support the view that it should be as fully organised by the Governments of a world at peace for its proper purposes of enriching life and enlarging the opportunities of happiness for all men alike. There were not wanting voices, however, such as that of our Biological Secretary, to sound a warning of dangers which might be entailed by such fulness of association between science and government as others were advocating with conviction and enthusiasm. Freedom and opportunity, it was pointed out, rather than organisation, provide the conditions for the highest types of research, and thus, in the end, for the greatest services which science can give to mankind. I find myself in sympathy with this view, and nobody here, I think, would suggest that it is usually possible to organise the researches which advance boldly into the unknown and open new vistas to human understanding. Here we shall certainly not overlook the fact that in the period between the two wars important funds have been placed at the disposal of the Royal Society by a series of generous benefactors, to be administered for the support of researches over a wide range of subjects in complete independence of any control by the State.

On the other hand, I think that it will be agreed that the remarkable development in

* Royal Society, December 1st, 1941. Presidential Address by Sir Henry Dale, C.B.E.—Abstract.

this country since 1914 of the State support of research administered by the three Research Councils, normally in relation to the needs and the activities of a nation at peace, has taken place without any obvious detriment or danger to the freedom of science. The Royal Society's former function of advising the Government directly on all scientific matters and of organising such systematic researches as were then undertaken in the public interest, has, of necessity, been shared and greatly diminished. We, as a Society, however, can fairly regard this development as in many respects a realisation of the plans and the dreams of our predecessors here ; and I do not think it fanciful to claim that our Society's traditions and standards have been still effective, through the influence of our Fellows on the Research Councils and their Committees, and through the filling of their chief executive offices by men of our Fellowship. As a whole-time research worker myself since 1914, under the body which became the Medical Research Council, and the senior now in that service, I can bear grateful witness to the freedom of opportunity which can exist under an enlightened organisation and control, exercised on behalf of the Government. I have no reason to suppose that the conditions are otherwise under the other research councils. Nor should we lose sight of the fact that a further large proportion of the free scientific research of the country is now indebted to support from the State through grants to the universities, administered without any trace of detailed Government control.

While therefore the existing mechanisms for the support of science by the State are doubtless susceptible of improvement at one point or another, I find no reason to fear any threat to the freedom of science from them, or from any natural development on those lines. Nor do I fear it from a wider use of the organised application of science and scientific method to problems of public welfare ; nor, again, from a more effective access of scientific knowledge to those responsible for government. A year ago Sir William Bragg told the Society of the formation of the Scientific Advisory Committee to the War Cabinet, under the chairmanship of Lord Hankey, with the President and two Secretaries of this Society as members *ex officio*. The representation of the Society has, indeed, been strengthened since then, and in a manner most welcome, by the fact that, though I have succeeded him *ex officio*, Sir William Bragg still gives his wisdom and experience to the work of that Committee as an extra member.

There is one direction, however, in which I do find some reason to fear for the freedom of science. If science should become entangled in controversial politics, through the over-eagerness of its advocates and champions to invoke the sanction of science, or to claim its potentialities, in support of any special political doctrine, then, indeed, I believe that the threat to its freedom might become a real danger. Let there be no misunderstanding of my meaning. I am not abusing the privilege of this Chair by using " controversial " as an epithet, to be applied to political opinions which I do not happen to share. I see danger if the name of science or the very cause of its freedom should become involved as a battle-cry in a campaign on behalf of any political system, whether its opponents would describe it as revolutionary or reactionary. If science were allowed thus to be used as a weapon of political pressure, it would be impossible to protect science itself eventually from the pressure of sectional politics. If that should happen, the dangers are, I believe, beyond dispute—the danger, for example, that fundamental researches, having no immediately practical appeal, would be allowed to fall into arrears through relative neglect, or the danger that the rigid standards of true science would be relaxed, by allowing the convenience of results for policy or for propaganda to enter into the assessment of their validity as evidence. This Society, with its firm and unbroken tradition of complete aloofness from political controversy, may still find it an important part of its function to keep watch and, if necessary, to stand without compromise for the right and the duty of science to seek the truth for its own sake, in complete freedom from any kind of extraneous influence. I hope, indeed, that there will never be need thus to invoke our tradition, to protect the freedom and the integrity of science from the enthusiasm and the advocacy of any of its friends.

Obituary

G. A. MOWER

WE greatly regret to learn of the death, on November 26th, in his eighty-second year, of Mr. George Augustus Mower, chairman of the Sturtevant Engineering Company, Ltd., the Igranic Electric Company, Ltd., the Bifurcated and Tubular Rivet Company, Ltd., and the Crosby Valve and Engineering Company, Ltd. Mr. Mower was born in the United States in 1860. He graduated at the Boston College of Technology and first visited England in 1883 on behalf of the Crosby Valve Company, and the B.F. Sturtevant Company, both of Boston, U.S.A. In 1884 he took up permanent residence in this country and founded the Sturtevant Engineering Company and the Crosby Valve and Engineering Company. Some years later he acquired a controlling interest in the Bifurcated and Tubular Rivet Company, which he reorganised. In 1898 he took up the agency of the Otler Hammer Company, of Milwaukee, and in 1913, in order to manufacture and further develop its patented control gear in this country, he founded the Igranic Electric Company. The prominent position occupied by these companies in their respective spheres bears witness to Mr. Mower's enterprise and organising ability.

Mr. Mower was a man of outstanding force of character, boundless energy and remarkable foresight. He was probably the oldest American resident in London, and had held prominent positions in connection with practically all the better-known American activities in this country. Although retaining the chairmanship of his many companies, ill-health prevented him in recent years from taking his former active part in their administration, so that his death, which is regretted by all who knew him and worked with him, will not affect the policy or activities of the companies with which his name will always be associated.

The Design of High-Speed Military Airplanes*

By CLARECE L. JOHNSON†

THE design of present military airplanes is changing so fast that any discussion of the subject is likely to be very far behind the latest trends by the time it is published. At the beginning of the war this was particularly true. It seemed that in a period of a few weeks many factors which should have been apparent in military designs made themselves known. The lack of armour, fuel tank protection, and ample armament required hasty revision of many outstanding types. After a short while, the air forces of the major military Powers could be evaluated in terms of their outstanding shortcomings or merits.

The success of Great Britain's eight-gun fighter and power turrets was one of the dominating factors in turning back Hitler's attacks last autumn. The foresight of the British in providing such fundamentally sound design elements cannot be too highly praised.

Perhaps the outstanding features of the German air force were its great use of the dive bomber, the highly co-ordinated tactical co-ordination between the air forces and ground troops, and its successful use of fuel injection engines and protected fuel tanks.

As the war developed, it became apparent that our own air force had called the tune very successfully with its development of the long-range four-engined bomber, which had been greatly criticised in Europe, the turbo-supercharger, and its prize bomb sight. While all countries had in some measure at least experimented with most of the above features, and in some cases had carried the respective developments (such as dive bombing) to high degrees of perfection, it is believed that the items indicated above were the outstanding elements in the air forces of the countries named from a point of view of technical development.

When the early war experience showed up the shortcomings of many service airplanes in armour, tank protection, and armament, a great hue and cry was raised in the United States, bemoaning the fact that our aircraft was so far behind the European types in these factors. Properly analysing the facts in the case, however, shows that, with the exceptions noted above, all the major air forces were very nearly on a par in being caught without proper protection and hitting power.

In this paper the discussion will be limited to a discussion of design trends of the high-speed military fighter, although many of the statements made apply equally well to all types of high-speed airplanes. In considering the fighter airplane, its basic purpose in intercepting and shooting down bombers must be considered. The success of the fighter in stopping daylight raids has been well known, but developments in tactics of night bombing have made very difficult the problems of night interception and fighting. A few simple figures can be used to point out some difficulties which are encountered when it is desired to stop a bombing raid.

A modern bomber flying 300 m.p.h. at 25,000ft. can stop both engines, feather the propellers and glide practically noiselessly for a distance of 45 miles before obtaining an altitude of 5000ft., 11 min. after starting its glide. This gives the bomber an excellent chance for surprise raids, particularly at night, when they cannot be seen. Naturally, the organisation of ground forces, black-outs, and various defence means are being developed to overcome the temporary advantage of the bomber, but the technical problems involved are very great. Considering the fact that our present bomber flying at high altitude with full power can add 100 m.p.h. to its speed in a shallow dive of only 5½ deg., it can be seen that sustained high speeds for long distances are obtainable when starting from high altitude. The new bombers of even cleaner aero-dynamic design, having high speeds approaching 400 m.p.h., can also add 100 m.p.h. at about the same angle of power glide. Starting at 30,000ft. in such a glide, the bomber covers 50 miles in a period of 6 min., while still having an altitude of 10,000ft. at the end of this time.

A pursuit plane ready to take to the air 5 min. after the bombing plane has been sighted must have tremendous performance to climb to altitude and catch the bomber at any point on its attack. Under conditions of this nature, a speed advantage of 50 m.p.h. seems to be the absolute minimum acceptable for the fighter airplane over the bomber.

One of the obvious answers to such difficulties, of course, is the continual patrol of

* Reprinted from the *Journal of the Aeronautical Sciences*, New York, October, 1941.

† Chief Research Engineer, Lockheed Aircraft Corporation.

fighter squadrons over all vulnerable points at all times of the day and night. Naturally, the number of aircraft required for such patrol becomes very large.

FACTORS EFFECTING DESIGN

The hardest problem which the designer of military airplanes must face is the proper evaluation of these fundamental factors in their relative importance, one to the other :—

(*a*) Performance.
(*b*) Armament.
(*c*) Ease of production.
(*d*) Manœuvrability.
(*e*) Time required for development.
(*f*) Flight qualities.
(*g*) Cost.

All aircraft design is made up of compromises between these considerations, and the success of the basic design depends on which of the above factors have been favoured without too great a loss in the other items. The element of time is of paramount importance under war-time conditions, because the manufacturer, or, more properly, the nation, cannot afford to gamble too far on new and untried design features for fear that trouble experienced in their development may make his airplane obsolete and waste his production facilities at a time when the greatest output is required. It is better to have 1000 400-m.p.h. airplanes in service than to have the finest 450-m.p.h. design in the world on paper struggling with problems of design and production. Only after sound fundamental research and the highest type of engineering can the manufacturer afford to use some of the newer developments now on the horizon of progress.

PERFORMANCE

One of the various items of airplane performance, the most important for the pursuit or interceptor type, is speed. Present tendencies in the war indicate that high speed should be obtained at as high an altitude as possible. At the time of this writing, service pursuit craft now being used have high speeds of 330 to 390 m.p.h. between 15,000ft. and 23,000ft. The types now in early production stages will reach 370 to 450 m.p.h. between 20,000ft. and

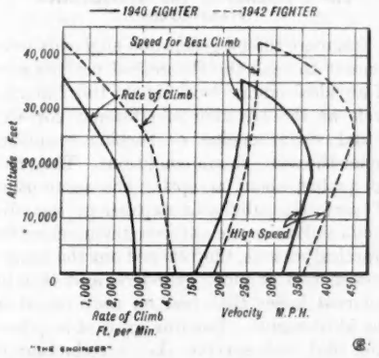


FIG. 1—*Comparative Performance of Typical Present Fighter and Probable 1942 Type*

30,000ft. In order to obtain such velocities, continual research must be directed on all phases of airplane engine and propeller design. Fig. 1 shows a comparison between the major performance characteristics of a typical present-day fighter and the improvements which might logically be expected for service airplanes in the near future.

A rapid tendency towards higher wing loadings and lower power loadings can be noted, brought about by the desire for higher speed and greater load-carrying ability of the fighter aircraft. Table I shows the effect of varying the wing loading only on the basic pursuit function of interception. A measure of the effectiveness of the fighter airplane is the distance it can cover in a given time from take-off, when considered for a certain operating altitude. For wing loading values now in sight, it will be seen that improved performance results with the higher wing loadings. The second factor which forces an increase in wing loading is the great increase in the weight of armament, armour, and power plants required for keeping in line with the bomber development. The effect of wing loading on manœuvrability seems to be gradually getting lost, due to the limitations of the pilot in withstanding

TABLE I

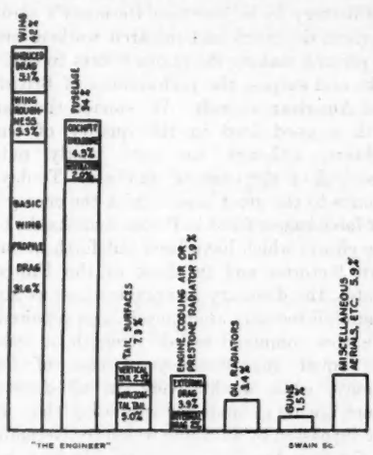
All airplanes designed to carry same engines, armour, armament and crew. Gross weights vary to account for difference in wing and tail weight. Stability is constant.

Wing loading.	Time to 20,000ft.	Max. speed 20,000ft.	Distance from take-off point after 30 min. (20,000ft. altitude).
Lb./sq. ft.	Min.	M.p.h.	Miles.
30	6·15	400	180
45	5·88	425	192
60	5·92	445	202

the load factors so easy to develop at high speeds.

DRAG

The relation of airplane drag and thrust horsepower for airplanes in the 400 m.p.h. class requires that extremely careful attention be given to the reduction of air resistance if the



Total airplane drag=100 per cent.; total thrust power at high speed=1041 H.P. (see Fig. 3)

FIG. 2—*Drag Breakdown for a Typical Single-engine Fighter Airplane having Performance shown in Fig.* 1.

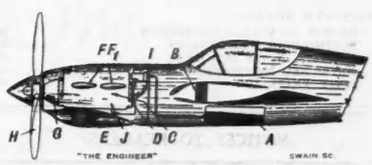
airplane size and power are to remain within the bounds of practicality.

The designer must continually attempt to make the smallest possible airplane for a given power and be sure that the drag of every element is as low as can be obtained without sacrificing stability, control, or maximum lift. Figs. 2 and 3 show the energy breakdown for a typical modern fighter airplane in the higher performance brackets. The drag of the various elements of the airplane has been reduced greatly from values in existence several years ago. There is still a possibility of a substantial reduction in the skin frictional resistance, roughness, and cooling drag. By using airfoils with shapes which extend the laminar flow area, the drag can be reduced considerably, but these wing sections must be considered from the point of view of manufacturing difficulties, maximum lift, and the effect of roughness which is inevitably encountered in service when flying off rocky fields or through hail storms. There is an undeveloped field requiring much additional research on this problem which seems to show much promise.

There has been little change in the heat rejection for cooling of our modern engines for several years. As engine powers increase and operating altitudes go up, the difficulties of providing sufficient cooling assume great proportions. While the projected area of modern engines has decreased, the size of the radiators required for cooling has increased to the point where the design of a modern military fighter attains the condition where practically all equipment items and structure must be developed around the power plant. Even though the projected area of liquid-cooled engines has been held down very well for the power obtained, the fuselage size encountered in the installations of such engines is generally disappointing to everyone concerned because of the problem of installation of superchargers, intercoolers, oil radiators, Prestone radiators and landing gear wheels of a size to take the weight of the engine involved.

The classic argument of the lower drag of the liquid-cooled engine *versus* the air-cooled type for a given power output seems no nearer solution now than it ever has been. The designers of the liquid-cooled engines enjoy drawing pictures of their liquid-cooled engines with fine pointed noses and faired shapes, forgetting to look back a few feet on the airplane and finding under the fuselage or in the wings the same type of air entrance that must be used for cooling the air-cooled engine. There is no theoretical reason and little practical evidence to show that lower drag per horsepower can be obtained with a liquid-cooled installation than can be obtained with the air-cooled type. In making a large number of comparative designs, it has also been noted that very little difference in the projected area or fuselage drag results for the two installations. As regards compressibility effects on cowling of the air-cooled type, it is as easy to avoid critical pressure distributions on a cowling nose as it is on a radiator duct.

When considering the drag of the single-engine fighter airplane, the remarkable aerodynamic cleanliness of the present type can be



Useful Power

G. Power out of engine, 1150 B.H.P.
H. Thrust horsepower out of propeller, 955 H.P.
F_1. Thrust horsepower from jet reaction, 86 H.P.

Heat Loss

B. Prestone radiator—heat rejected to Prestone, 400 H.P.
C. Heat lost to radiation, oil vaporisation and crank case cooling, 550 H.P.
D. Power to supercharging and engine accessories, 118 H.P.
E. Oil radiator—heat rejected to oil=110 H.P. (friction power).
F. Jet exhaust—heat rejected to exhaust gas, 3402 H.P., includes heat content of unburned fuel used for cooling (1300 H.P.) pressure loss in exhaust system, &c.

Power Input

A. Fuel tank—power input, 115 gallons fuel per hour, 14,600,000 B.Th.U. per hour or 5730 H.P.
I. Carburetter.
J. Engine.

FIG. 3—*Energy Balance for Typical Military Engine—Operating at Maximum Power Output*

shown by comparison with an equivalent flat plate area. The total drag for such an airplane at any given speed is no more than that of a flat plate 22in. square. The poor designs, however, run up to twice this drag figure. A good twin-engine fighter can be represented in drag by a flat plate 27in. square.

(*To be continued*)

PLASTICS FOR CABLE MAKING.—In an inaugural address delivered recently by Mr. S. W. Melsom to the Transmission Section of the Institution of Electrical Engineers, the speaker said that four distinct groups of plastics were under consideration for cable use. Polyvinyl chloride compound had been employed for extreme conditions, and was proving satisfactory both as an insulation and as a protective sheath. The dielectric properties of this plastic were no more than moderate, but it was unaffected by oxygen, oil, acid, &c., was resistant to flame or fire, and under ordinary conditions might be termed indestructible. Development was proceeding at a great rate, particularly now that cable technicians were co-operating with plastics chemists, and plastics soon might play an important part in the rubber cable industry. There was some evidence that a mixture of rubber and high-grade plastic material gave satisfactory results.

The Engineer

DECEMBER 5, 1941

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The fact that goods made of raw materials in short supply owing to war conditions are advertised in this paper or described in its editorial columns should not be taken as an indication that they are necessarily available for export.

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CHANGES OF ADDRESS

*** *Will Subscribers please note that in all advices regarding changes of address it is necessary to have* **both old and new address,** *as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

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GERMAN AIRCRAFT DEVELOPMENTS

COMMENT has been aroused by recent announcements made by the Germans concerning the deaths of four highly placed officers of the *Luftwaffe*, Generals Wilberg and Udet and Colonels Moelders and Von Werra. In each case the enemy has made it clear that these officers did not meet their deaths in the field of battle, but died as a result of an accident while flying, while testing a new instrument or weapon or in some other non-combative manner. By some people in this country a sinister and purely political interpretation has been placed on this sequence of casualties, the suggestion being that these officers have been "eliminated" for daring to oppose their leader's Russian campaign and for criticising the severe loss of aircraft and air crews which it has entailed. If that is the explanation of their deaths we can have nothing further to say regarding them. An alternative suggestion, however, provides us with a reason for expressing considerable technical interest in what may lie behind them. It may be, it is said, that these four officers lost their lives while testing new types of aircraft or new forms of aerial equipment. The enemy himself has hinted as much. Wilberg, the German radio announced, had been engaged since 1939 in a new field of action. Udet's career during and since the war of 1914–18 is certainly in keeping with the suggestion that he would be chosen to test and experiment with new aeronautical equipment.

It is neither "wishful thinking" nor vain self-flattery to believe that Germany's aeronautical designers and research workers are at present making strenuous efforts to overtake and surpass the performance of British and American aircraft. We started the war with a good lead in the quality of our fighters, although we were vastly outmatched on the score of numbers. To-day, thanks to the great losses which the enemy's air force has suffered in Russia and thanks to the efforts which have been put forth in our own factories and in those of the United States, the disparity in numbers has, as Mr. Churchill recently announced, been repaired. We now command an air strength at least the equal quantitatively of that of the enemy, while qualitatively, in all classes, there are no grounds for supposing that we are surpassed by anything which the Germans so far have brought against us. It may, we think, be taken as certain that the enemy now realises that if he is to avoid overwhelming defeat in the air his only remaining chance is to spring upon us in large numbers aircraft with greatly increased performances and, if possible, with new characteristics leading to a new technique of employment. In the Battle of Britain we gave them a forcible lesson that a small number of aircraft of superior design and resolutely handled can be more than a match for mere numbers. It would be foolish to suppose that the Germans allowed their pride and self-assurance to blind them to that lesson and that now in the hour of their urgent need they are failing to apply it. In what direction can they hope to find a chance of success? They are said to be pressing forward frantically and desperately with new types of aircraft, some of them being of revolutionary design. One direction which they are stated to be following is the construction of heavily laden bombers, the take-off of which will be assisted by "rocket propulsion." The interest displayed in Germany before the war in the rocket propulsion of missiles and land vehicles provides some support for the truth of this assertion. Whatever be the exact nature of the means employed, the end in view is certainly one of great practical desirability. We recall the interest which our own Air Ministry displayed at one time in Sir Alan Cobham's refuelling system and in the Short-Mayo composite aircraft, both of which inventions had as their object, or one of their objects, the assisting into the air of aircraft too heavily laden to climb to operational height under their own power.

It is reasonable to believe that the Germans are making strenuous, if not "frantic and desperate," efforts to produce aircraft of outstandingly improved performance and probably new operational characteristics. It is, however, doubtful whether under present conditions they will be able to produce in time anything which will redress decisively to their advantage the aerial situation as it now exists. New bombers with increased load-carrying capacity will do little more than place the enemy on a parity with the Royal Air Force and its present equipment of "Stirlings," "Manchesters," "Fortresses" and other British and American heavy-weight aircraft. To exert anything like a decisive effect the Germans must overtake us, not only in the quality of our bombers, but in the quality of our fighters and, further, must now do so in a manner which will give them also quantitative superiority. It is a formidable and, we are happy to believe, an impossible task at this late hour. They may enslave all the aeronautical factories of Europe for the production of aircraft, but to wrest qualitative superiority from us they must rely on their own designers and research workers. It is one of the lesser emphasised virtues of the co-operation now prevailing between this country and the United States that it not only places at our disposal the ever-growing output of the American aircraft industry, but releases for friendly and whole-hearted co-operation with us a body of designers and research workers possessing unrivalled facilities and acknowledged abilities for effecting improvements and developments.

The Efficiency of the Regenerative Heat Cycle

FOR more than a generation engineers were content to take the theoretical performance of an ideal engine working on the Rankine cycle as the criterion of efficiency for any actual steam engine or turbine operating under the same steam conditions. They had no qualms about accepting the assumption of perfectly adiabatic expansion, nor did they think the cycle unfair to them, when; for practical reasons, they carried out the expansion in two or more cylinders, and thereby incurred losses that had no counterpart in the ideal engine. But this spirit of acquiescence did not survive the introduction of regenerative feed heating. The Rankine cycle then no longer represented the ideal to be aimed at, and there was unfortunately nobody with the authority of a Rankine to say what the new ideal should be. It is true that the Heat Engines Trials Committee of the Institution of Civil Engineers considered the question in 1927, but its recommendation did more to confuse the situation than to clarify it, and has been generally ignored. The result is that, even to-day, a quarter of a century since Parsons inaugurated the practice of regenerative feed heating by installing a turbine working on this principle at Blaydon Burn, there is no generally accepted method of calculating the ideal efficiency of the regenerative cycle.

There are, broadly speaking, two conflicting views on the matter. The more logical one is that the ideal plant must be thermodynamically reversible in every process, as

otherwise the maximum amount of work could not be obtained from the temperature drop of the working substance. If this is admitted, and one would think that it must be, it follows that the feed heating must be considered as taking place by infinitesimal increments, or, in other words, that the ideal plant would be equipped with an infinite number of little feed heaters. Such an assumption seems not only theoretically necessary, but it has the great practical advantage of making the task of computing the theoretical efficiency of a regenerative cycle as easy as that of the old Rankine cycle. In either case, one has only to look up five numbers in the Steam Tables and do a little sum in elementary arithmetic. The whole procedure is thus exceedingly simple and rapid, and it needs no modification even if steam in the superheated state is tapped off for the final stages. The other point of view is based on the conviction that it is unfair to compare the performance of an actual plant having perhaps only three or four stages of feed heating with an ideal plant having an infinite number of stages. This argument may appear plausible, but it is fundamentally unsound. The ideal plant must of necessity be conceived as having an infinite number of stages, for otherwise there would have to be thermodynamic irreversibility due to hot steam giving up its heat to cooler water, and the plant would no longer be ideal for the reason already mentioned. There is, moreover, no objection to giving the ideal plant a characteristic impossible of attainment in practice, for every one of its other attributes is equally impossible. If one thinks it not unfair to compare the performance of an actual turbine with that of a perfectly frictionless machine, made of metal which is absolutely non-conducting of heat in some parts and infinitely conducting in others, and working with steam that will expand under perfectly isentropic conditions, it is surely a small thing to add one more perfection to this accepted collection of wonders.

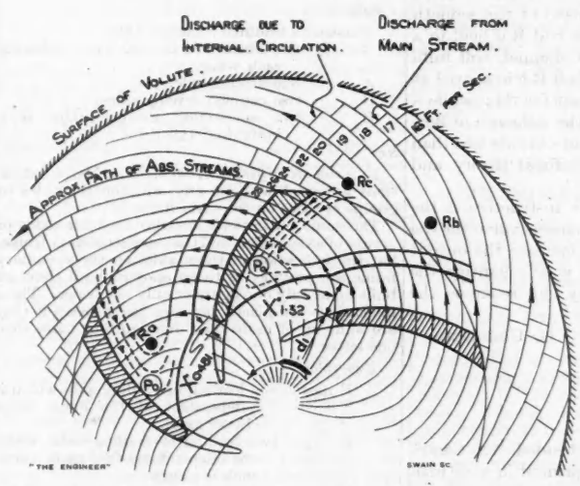
The extraordinary complications that result from attempting to perform the logically impossible task of correlating a cycle involving feed heating by stages with the conception of an ideal plant is well illustrated in a paper by Mr. H. S. Horsman, which is published in the November *Journal* of the Institution of Mechanical Engineers. The author has done an immense amount of work in his efforts to provide engineers with some method of computing the ideal efficiency of a regenerative feed-heating cycle when the number of heaters is limited, but, even so, he has had to base his process on assumptions which are open to at least as much criticism as is the simpler conception of feed heating by infinite stages. For example, one of the conventions on which he has founded his theory is that the feed water will leave every heater at the full temperature of the heating steam. This is a perfectly legitimate postulate for an ideal plant, but it obviously requires every heater to be conceived as having an infinite size, because as the water approaches its final temperature, the rate of heat transmission will become infinitely slow. And if one has to think of the ideal plant as equipped with a few infinitely large heaters, one might just as well imagine it to be provided with an infinite number of small heaters, for both conceptions are equally remote from reality. Another of his conventions is that every feed heater in his ideal plant shall contribute an equal temperature rise to the water, a condition which is rarely, if ever, aimed at in practice. But the overwhelming objection to considering the number of feed-heating stages when comparing the thermal efficiency of an actual engine with that of a perfect engine lies in the fact that, in the conception of a perfect engine, there is no place for any question about the number of feed heaters. Such an engine can only be defined as one that will convert into useful work the whole of the heat theoretically available for this purpose. Now, with live steam at any given pressure and temperature, any given vacuum, and any given temperature of regenerative feed heating, the heat available for work is a perfectly definite quantity. If any engine, by reason of its feed-heating arrangements, is debarred from taking advantage of the whole of this available heat, it is not a perfect engine, and has no right to pretend to be one. Its cycle of operations is one that is marred by a theoretically avoidable thermodynamic loss, and this being the case it fails to qualify as a criterion of efficiency. The plea that we cannot provide a real engine with an infinite number of feed heaters is beside the point. If we were to debase the conception of a perfect engine in one respect, there is no reason why its other virtues should not be encroached upon, and we should be faced with proposals to allow it to have a little friction, or to depart from adiabatic expansion, and so on, as a concession to the frailties of actual machines. Only so long as we hold firmly to the conception of a perfect engine as one free from all thermodynamic losses are we on sure ground. As we have already pointed out, the calculation of the thermal efficiency of such an engine when working with any specified conditions of steam and feed-heating temperature presents no difficulty whatever, while it provides us with the only valid criterion of the efficiency of an actual engine working under the same conditions, whatever be the number of feed-heating stages.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

VISUAL EXPERIMENTATION WITH CENTRIFUGAL PUMPS

SIR,—You have to be thanked for the very interesting article under the above title which you published in your issue of THE ENGINEER, October 24th, page 278, giving an outline of the very exhaustive experiments carried out by Lieut.-Com. Howard L. Cooper, U.S.N.R., with the use of a model dredging pump at the U.S.E.D. The author suggests, in the last paragraph, that the paper will provide more questions than answers. It is hoped that this communication, as well as suggesting questions, will provide at least a basis for acceptable answers.



The depth of water Xin. over the vane tips at the inlet to the channels can be calculated from the formula $\text{Xin.} = \frac{720 \times f}{\text{r.p.m.} \times Z}$, where f = the radial velocity in feet per second at d_1, and Z = the number of vanes. The approximate values of Xin. for runs 1 and 4 are shown in the accompanying sketch of impeller A. The left-hand channel shows the volume occupied by one-fifth of the quantity delivered by the pump, 0·481 cubic foot per second during run 1; while the right-hand channel shows the corresponding condition during run 4 when passing 1·32 cubic feet per second. It will be observed that since the cross-sectional area of the stream varies directly with f, the formula shows that the relative velocity in the channels varies little over the range of output considered, and it also follows that the same remark applies to the contour of the absolute streams, the exit diagrams and the volute velocity. It is to the uniformity of the volute velocity that the writer's attention has been directed by the valuable investigation carried out by Mr. Cooper.

This uniformity is best illustrated in Fig. 2, page 279, by the similarity of the velocity contours in sections C C, D D, and E E—that is, in the half of the volute remote from the disturbing influence of the discharge branch or nipple. That a constant volute velocity over a wide range of output appears to be a characteristic of centrifugal pumps can be seen from a study of the sketch. The absolute velocity of the streams discharging from the impeller, given by the exit diagram, will be about 28ft. per second. Beyond the influence of the vanes the streams have been shown stepped to indicate the reduction in the absolute velocity outwards, due to their approaching a region of higher pressure, *i.e.*, the outer radius of a bend. The inertia or momentum of the streams—they

might almost be considered as extensions of the impeller vanes—will carry the fluid round the volute at the same angular velocity as the impeller, thus giving the effect of a constant volute velocity. If this be the correct interpretation of the velocity contours obtained by Mr. Cooper, it may explain his difficulty—as shown by the graphical illustration of the phenomenon given in Fig. 2—of comparing the velocity in the nipples, which varies directly as the quantity, with a constant volute velocity. It may also account for his disappointment at the striking results obtained after fitting the tongue extension. The turbulence losses caused by bringing the tongue so close to the impeller periphery is probably the correct explanation.

The only difference in the impeller channels and volute caused by a change in output will be a corresponding change in the depth of the main stream or the ratio, volume of main stream to deadwater volume. It is doubtful, however, if "deadwater area" or "volume" is the correct expression to use, as it is considered that internal circulation may occur in this space. The dotted lines in the channels represent a possible inward flow, relative to the impeller, from the volute towards P *o*, the approximate position of the region of the lowest pressure in the system. This inward flow, added to the main stream, means that the impeller discharges a larger volume than that actually delivered by the pump, until at some point as the pump discharge increases and the head decreases, the inward flow will cease and the "deadwater area" in the channels of the impeller will be empty.

The continuous and stroboscopic study of the movements of rubber balls in the pump provides three facts which may be difficult to reconcile with orthodox text-book theory. These are (*a*) a ball can remain in the impeller for several revolutions; (*b*) it can also recirculate round the volute; and (*c*) the fact most at variance with centrifugal theory, a ball can move inwards from the volute and re-enter the impeller. On the other hand, the interpretation of the physical behaviour inside the pump, indicated by the sketch, provides a reasonable explanation of the facts. Remembering that swirls, eddies, and in some cases extreme turbulence will take the place of the smooth streamlines shown, a rubber ball R *a* held in a vortex, formed at R *a* in a channel, will fulfil condition (*a*); similarly, a ball R *b* in a swirl at R *b* in the volute will account for (*b*); while a ball at R *c*, coming within the influence of flow due to internal circulation, at outputs less than the normal, will defy centrifugal theory and illustrate case (*c*).

It would have been very instructive if the test arrangement had included a valve on the delivery side, to gradually increase the output to observe, if possible, at what quantity the balls showed no tendency to re-enter the impeller.

G. URE REID.

Dollar, Clackmannanshire,
November 28th.

SIR,—In your editorial headed "A Centrifugal Pump Experiment," printed in your issue of October 24th, it is noticeable that you find occasion to refer to pump efficiencies "in excess of 90 per cent," when discussing some very interesting phenomena observed in an experimental pump whose efficiency was nearer to 70 per cent. Surely the very reason why the one pump gives the extraordinarily high efficiency is that its internal action differs from that of the lower efficiency pump, in that the wasteful turbulent regions, observed in the one, are absent from the other.

You also draw attention to the visual results obtained by circulating rubber balls through the pump, but apparently have not noticed that the balls were of "specific gravity slightly lower than that of water." When rotated, these balls are forced towards the pump axis because the volume which they occupy possesses greater energy as water than as the lighter ball. Hence the behaviour of the balls does not truly represent the behaviour of the water. This might have been shown if the movements had been checked by repeating the tests with slightly heavier balls.

OWEN A. PRICE.

Kilmarnock, November 19th.

LOCOMOTIVE WHEEL NOTATION

SIR,—With reference to the letter of Mr. Livesay which you published in your issue of November 21st, it seems hardly necessary to introduce a new locomotive wheel notation in view of the fact that this subject is fully covered for locomotives, railcars, and tenders by specification 0.104, issued on January 1st, 1938, by the Union Internationale des Chemins de Fer, or International Railway Union (U.I.C.), under the title "Symboles Mécaniques pour Véhicules Moteurs" ("Mechanical Symbols for Power Vehicles"), of which I attach an extract. The adoption and use of this specification was compulsory (*obligatoire*) for all railways members of the U.I.C.

C. CARTY.

London, W.C.1 November 28th.

UNION INTERNATIONALE DES CHEMINS DE FER
No. 0.104.
1.1.38.
Vth Commission,
Technical Questions
(Electricity Section).

STANDARDISED INDICATION OF THE AXLE ARRANGEMENT ON LOCOMOTIVES, RAILCARS, AND TENDERS

1. *Axles on One and the Same Frame.*—The leading and trailing axles are indicated by Arabic figures, the value of which gives the number of succeeding axles of the same nature.

The driving axles are indicated by means of capital Latin letters without index when coupled together, with the index "0" (zero) if they have an individual axle drive. The position of these letters in the alphabet gives the number of succeeding axles of the same nature.

[No indication is provided to indicate the absence of leading or trailing axles.]

Examples.—

1 means a leading or trailing axle.
2 ,, two leading or trailing axles following each other.
A ,, one driving axle.
B ,, two coupled driving axles.
B_o ,, two succeeding driving axles with individual axle drive.

&c.

2. *Axles on Different Frames.*—The above indications are used without any addition for axles or groups of axles on the main frame.

The same indications are also used for axles or groups of axles on one and the same secondary frame, but the indication of these axles on the secondary frame are provided with an apostrophe if they are built up of only one figure or only one letter. These indications are placed between parentheses if they are built up of more than one figure or more than one letter.

Examples.—

1' means one leading or trailing axle which is independent of the main frame (Bissel axle).
2' ,, two leading or trailing axles which are independent of the main frame, such as a bogie.
A' ,, one driving axle independent of the main frame.
B' ,, two driving axles coupled within a bogie which is independent of the main frame.
(1 A) ,, one secondary frame provided with one leading axle and one driving axle.
(1 C) ,, one secondary frame provided with one leading axle and three coupled driving axles.

&c.

Axles used as trailing axles, which, by means of an auxiliary mechanism, can be used also as driving axles, are indicated by small Latin letters.

3. *Tenders.*—The tenders are indicated by means of the capital letter T. The indication of the arrangement of the axles corresponds to the principles adopted for locomotives and railcars. This indication is placed a small space ahead of the sign T.

[Attached to the foregoing preamble are diagrammatic arrangements of different types of locomotives, railcars, and tenders. Included with these diagrams are some representing a *tender moteur* (a tender fitted with booster).]

SIR,—Mr. Edward H. Livesay, in your issue for November 21st, page 356, says "that L.N.E.R. 'No. 10,000,' sometimes called a 4–6–4 . . . is incorrect." But is it not Mr. Livesay who in this instance is himself "incorrect"? As I understand it, the usual notation is based on the principle that driving and coupled wheels (all live or adhesion axles) are added together, and carrying wheels, whether fore or aft, grouped together, being prefixed or affixed after, as the case may be. It seems immaterial to me whether the driving and coupled axles are referred to in figures or by letters. In the *Railway Magazine* for February, 1938, page 141, the matter was clearly argued out, and the accompanying table gives examples, both in all figures and in letters, for the driving and coupled wheels; A=singles, B=four-coupled, C=six-coupled, D=eight-coupled, and so on. To show the futility of Mr. Livesay's argument, the instance he cites of the Webb "Greater Britain" being described as a 1–1–1–1 is sufficiently clear. It is obviously a 2–2+2–2 or 2–A+A–2, in the same way that "No. 10,000" is a 4–6–4 or 4–C–4, but certainly not a 4–6–2–2 (or some other confusing notation). Booster wheels should be regarded as live axles and treated accordingly in the manner indicated below:—

Type of locomotive.	Usual notation.	Incorrect notation.	Alternative notation, using letters.
L.N.E. "No. 10,000"	4–6–4	4–6–2–2	4 C 4
"Great Britain" (B.G.), G.W.R.	4–2–2	2–2–2–2	4 A 2
8-footer, G.N.R. ...	Ditto	—	Ditto
Johnson singles, M.R.	Ditto	—*	Ditto
"Greater Britain," Webb, L.N.W. compound	2–2+2–2	2–2–2–2	2–A+A–2
Webb compound tank	2–2+4–0	2–2–4–0	2–A+B–0
"Liverpool," Crampton 8-footer (1848)	6–2–0	2–2–2–2	6–A–0
Gresley "Mikado,"* 2393–4	2–8+2–0		2 D+A–0
Ditto†	2–8–2		2 D 2
Gresley "Garratt," 2395	2–8–0+0–8–2		2D0+0D2

* Booster cut in. † Booster cut out.

JAMES F. VICKERY.

Westcliff-on-Sea, Essex, November 27th.

PEACE AIMS

SIR,—Mr. Robinson admits the necessity of maintaining a stable exchange, but once again he does not explain how it is to be done. Obviously, his scheme for increasing purchasing power would result in the necessity for importing much larger tonnages of raw materials, and these raw materials would have to be paid for. I know of no way of paying for these except by increasing our exports of goods or services. If Mr. Robinson knows of any other means of maintaining a stable exchange, it would be very interesting to be supplied with further particulars. Personally, I can see no means of escaping the inevitable necessity of paying for what we import. The creation of additional purchasing power, unless accompanied by a corresponding increase of export trade, can, in my opinion, only have one result. It appears to me that Mr. Robinson evades this issue.

A. SHEPPARD.

King's Lynn, November 29th.

SIR,—It is evident that Mr. Robinson possesses a wide knowledge of our financial

machinery and commands powers of keen analysis. Unfortunately, his desire for a monetary panacea inhibits his going on to the point where his own reasoning would expose the social credit fallacy. He admits that the alleged deficiency of purchasing power in one cycle of production is overcome by the commencement of another cycle. Yet he persists in the doctrine that at the end of every cycle of production there must remain sufficient purchasing power generated during that cycle to buy all its products. No one cycle of production is self-sufficient, for if it were there would be no goods in existence to sustain a fresh cycle. Figuratively speaking, the goods made yesterday are bought to-day with the wages paid to those who are making goods for to-morrow.

It is difficult to understand this prejudice against bank credit and bank interest. Bank interest is no more a subtraction from purchasing power than the cost of retail distribution. Both are added to the cost of the goods, and what is added is given back to the fund of purchasing power when banks and retailers bear the respective costs of their businesses.

Money is "created" by bank loans to finance the "creation" of goods. When the goods are sold and destroyed by consumption, the loans are repaid and the credit cancelled out of the proceeds of sale. Then, normally, the process is repeated. So long as there is no decline in the total of bank deposits there is no reduction in purchasing power. If all this bank credit, through a succession of loans, could be kept in existence when the goods concerned were consumed, the result would be credit inflation on a truly colossal scale.

Consideration for your space compels me to omit comment upon many other points in Mr. Robinson's letter, but I venture in conclusion to suggest that too much emphasis is placed upon the power of the banks to create credit, while the useful services they render in return are frequently ignored. Rights cannot be properly considered without regard to the duties they impose.

E. BISHOPP.

Harrow, December 1st.

DEVELOPMENT OF THE STEAM LOCOMOTIVE

SIR,—During the present crisis little interest in future locomotive development can be expected, so the able address and articles appearing in your issue of November 7th will not attract the attention they deserve. Let us hope they will not be lost sight of.

The last paragraph of Mr. Poultney's article cannot be too strongly emphasised.

Whilst further improvement in the freedom of exhaust is desirable, it is as nothing in relation to the necessity of improving the freedom of admission if a really satisfactory high-speed single-expansion locomotive is desired.

In order to take full advantage of boiler pressures above 200 lb. per square inch, a cut-off of 15 per cent. or less is necessary, and in this position of the conventional valve gear the port opening is only about one-quarter of an inch, and the time open only about one-thirtieth of a second at usual high speeds, so wire drawing is excessive, and as compression commences about half-way on the return stroke, the combined effect causes the power to be very much less than would be obtained under ideal conditions.

Although electric indicators which do away with inertia effects and long connecting pipes are not yet perfect, they were developed sufficiently before the war to show what was happening in the cylinders at high speeds, and confirm the above statements.

Existing conditions must be accurately known before we can set about improving them, but, unfortunately, reliable performance curves cannot be obtained from locomotives in ordinary traffic as conditions vary too rapidly. Constant speed testing is necessary, and a description of a method used in this country is given in your issue of August 5th, 1938. Not many tests had been made before the war, but valuable information was being obtained.

In the running positions customary at 40 m.p.h. and above, it was found with modern express locomotives that the peak of the drawbar horse-power curve occurs at about 50 m.p.h. in the earlier cut-off and at slightly higher speeds as the cut-off is increased.

The statement that back pressure increases with speed is only partially true; it does not do so at speeds above 60 m.p.h. in the earliest cut-off positions. If the port opening could be much increased in these positions and the compression and clearance volume reduced, the horsepower curve would be raised and the peak would occur at a higher speed, which, together with lighter reciprocating parts, would constitute an outstanding advance.

It is very doubtful whether this could be accomplished with the conventional valve gear, but, given unselfish team work, much patience, and reasonable ingenuity, it should be possible to effect this big improvement.

A LOCOMOTIVE ENGINEER.

Darlington, November 28th.

Construction Work for the United States Army

EVEN in the United States it is not generally realised what an enormous programme has been carried out to house its rapidly expanded Army and to equip it for effective defence and protection against attack. A review of this extensive and comprehensive programme was given by General B. B. Somervell, Chief of Construction, U.S. Army, at the annual meeting of the American Society of Civil Engineers, held at Chicago in October, and the following is a brief abstract of this address.

One year ago this huge inland industrial fountain of fighting strength did not exist, but to-day its machines are humming and pouring forth an ever-increasing stream of munitions. Meantime, more than a million soldiers are newly housed in the finest quarters and training camps ever built. A year ago the draft had not gone into effect and the construction programme had just begun. It now represents an investment of three billion dollars in national defence, and could not have been planned or carried out without the skill and loyal services of the American civil engineer. This emergency construction programme of 1940–41 is the story of the engineer, architect and builder.

To the Construction Division, U.S. Army, fell the responsibility of building shelter for 1,500,000 officers and men, and also facilities for the manufacture or storage of arms, ammunition, equipment and supplies. The first responsibility has been discharged, camps and cantonments having been in readiness in June, 1941. The camps were occupied progressively as they became available, some of them occupied before the end of 1940. The Army has been criticised for the speed and expense of the work, but the answer is that the Army has been housed on time, and we hope in time.

Subsidiary to the raising of a competent force was the provision of ammunitions and weapons for training and fighting. Here we had to start from scratch to overtake a competitor who had a seven years' start and who has added to his own productive capacity by enslaving the men and machinery of the nations he has conquered. Making allowance for sabotage by this rebellious subjugated labour, it will take sweat, speed and sacrifice to catch up with these additional manufacturing facilities. Many of our ordnance plants, as well as the hospitals, harbour defences, storage depôts, air facilities and other projects launched only a year ago, are now going concerns. Many of the plants have been producing far in advance of expectation. Powder is now coming from the assembly lines, T.N.T. is in production, bag loading has begun and shells are being loaded. Little appreciated outside engineering and construction circles is the magnitude of the achievement in completing these great manufacturing enterprises at such an early date. In 1942, thirty more ordnance factories will add to the spectacular volume of lead and steel production.

The first Army to take the field in the present emergency was the Construction Division of the Quartermaster Corps, which with 500,000 men constituted the "shock troops" of preparedness. It still numbers more than 400,000 and is working double shifts on production and storage facilities, while four division camps are under construction. On every job the engineer or engineer architect has played a leading *rôle*, and in the early days of the programme he was often but a few steps ahead of the contractor. The engineering problems encountered were neither simple nor routine, but frequently taxed the ingenuity and resources of the most experienced men.

There is little that goes into a modern city in the way of engineering that is not to be found in the large cantonments, and little in industrial engineering that is not found in the manufacturing plants. The railways, roads, water supply lines, tanks and reservoirs, sewers, water and sewage treatment plants, dams, gas and electric lines, bridges, tunnels and other works present all the problems to be found in the book. Many new methods have been evolved to solve problems not in the books. The Construction Division has spared no effort to obtain the services of the most prominent members of the profession, and scores have answered the call. Their skill, judgment and integrity are even more urgently needed for the months ahead. The engineer must be depended on more and more to streamline construction activities and to develop new means of making progress. Furthermore, he is our chief reliance in planning future activities, as he will be in making the plans a reality.

We have done a lot, but not nearly enough. We have much more to do. That is the inevitable prospect, if conditions do not soon improve in Europe. This is the grim job of arming so that we can really defend ourselves. Much as we appreciate the gallant stand on the other side of the water, we are not helping them for either charity or sentiment. We are not building camps and powder factories and air bases and military works for fun or exercise. It is all a matter of self-interest, dictated by necessity. It is better to work now with everything that is in us than to wait and wait and perhaps be defeated in the end.

BRITISH STANDARDS INSTITUTION

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria Street, London, S.W.1. The price of each specification is 2s. 3d. post free, unless otherwise stated.

FORGINGS FOR SHIP AND MARINE ENGINE PURPOSES

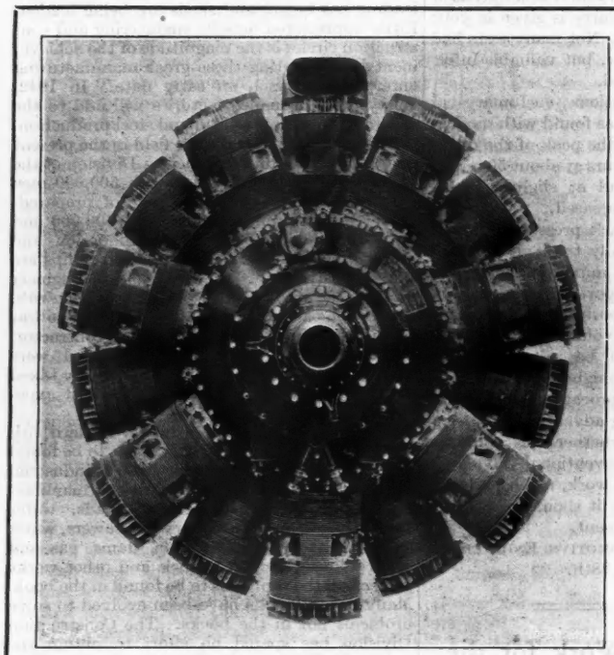
B.S. 29—1941. This is a revision of an earlier specification. The principal modifications are as follows:—(1) Provision has been made for four grades of steel covering ultimate tensile stresses ranging from 22 to 40 tons per square inch, and also for a reduction in the figures for percentage elongation and internal radius of the bend; (2) steel made by an electric process has been included; (3) maximum limits for sulphur and phosphorus have been imposed.

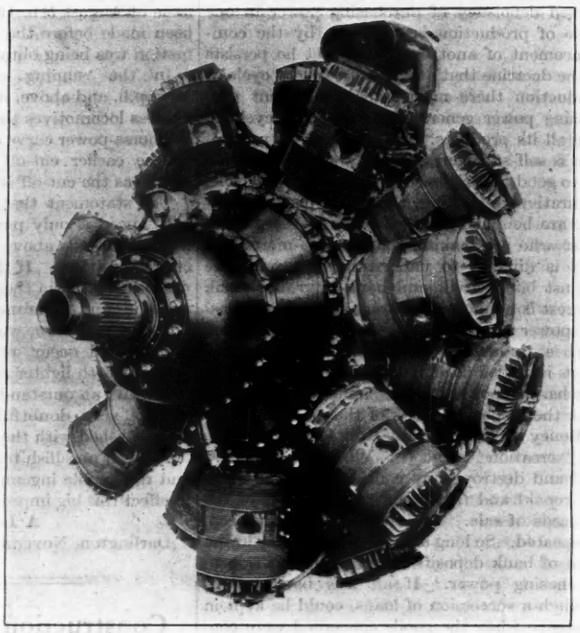
CABLE GLANDS AND SEALING BOXES

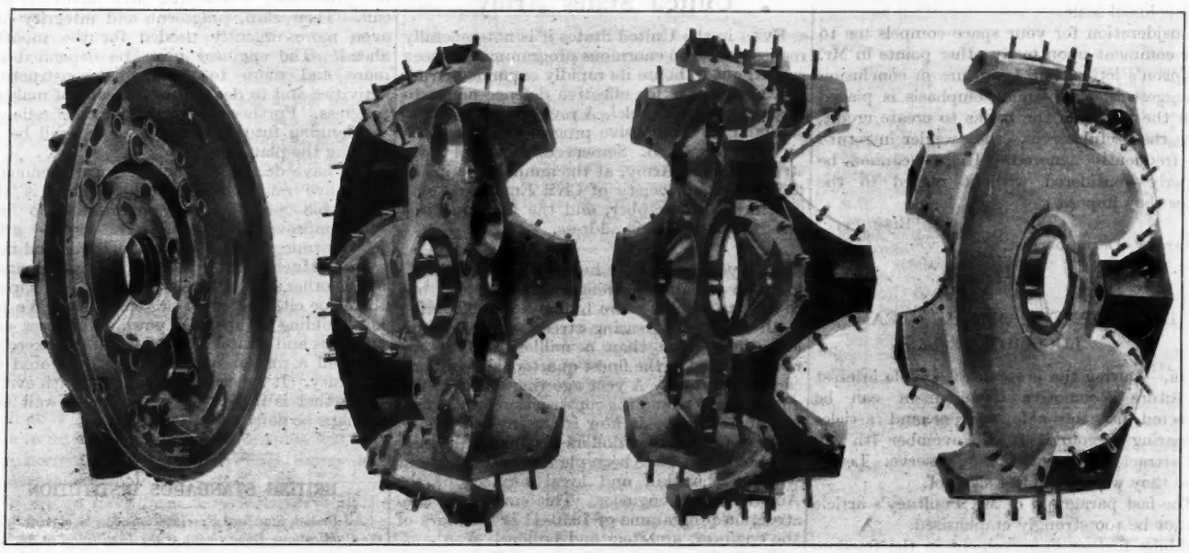
B.S. No. 542. This revision forms one of a series of British Standard Specifications for Colliery Electrical Equipment. The Colliery Industry Committee has endeavoured to secure an agreed series of standard facings for electrical machinery for use underground, in order that standard cable glands could be attached without change when machines or gear were taken out for repair or overhaul. So far they have not been able to secure agreement on these standard facings, but feel that in the meantime this revised edition will be of assistance to the standardisation of colliery requisites.

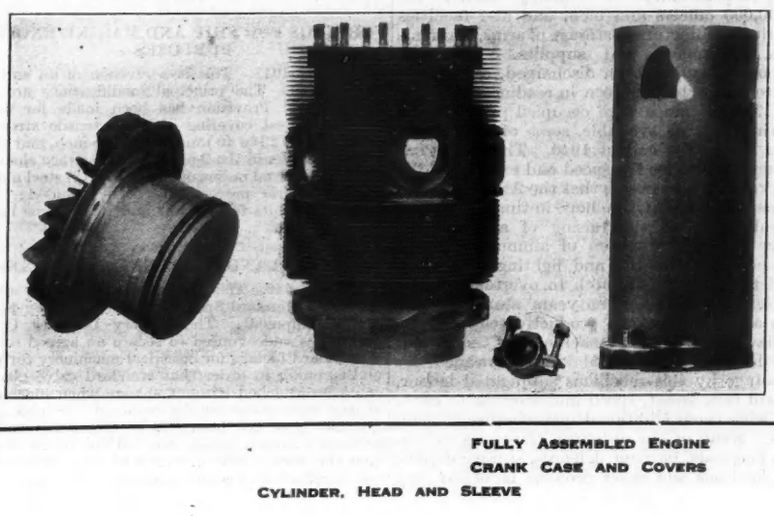
ASSEMBLY AND PARTS OF BRISTOL "HERCULES" AERO-ENGINE

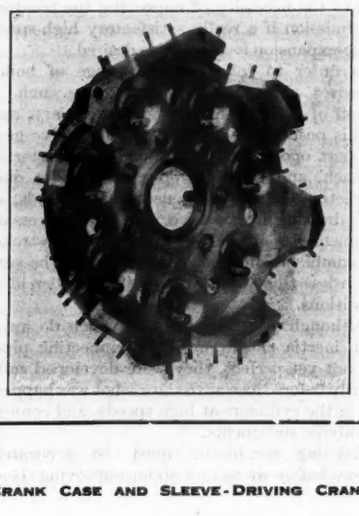
(For description see opposite page)











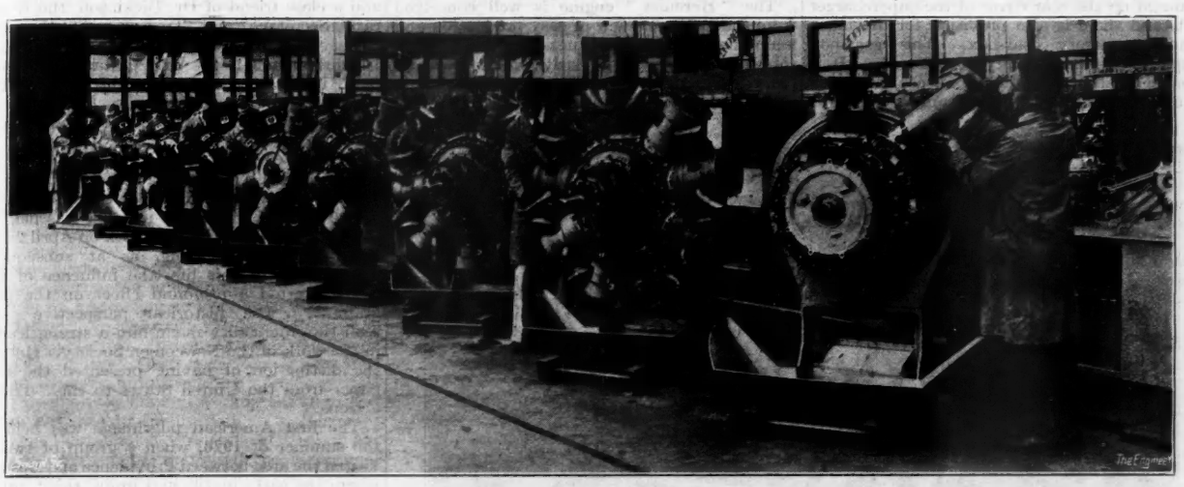
FULLY ASSEMBLED ENGINE

CRANK CASE AND COVERS

CYLINDER, HEAD AND SLEEVE

CRANK CASE AND SLEEVE-DRIVING CRANKS

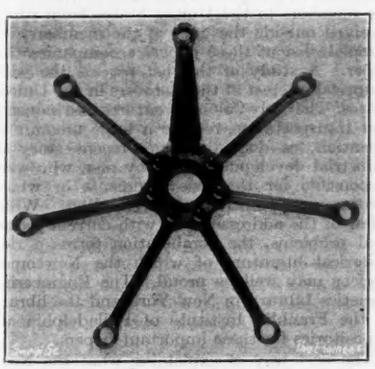
ASSEMBLY LINE FOR PRODUCTION OF "HERCULES" AIRCRAFT ENGINES



The Bristol "Hercules" Aero-Engine

IN the publicity rightly given to the achievements of the Royal Air Force with its high-performance types of aircraft, the equally important part played by the modern high-power aero-engine is apt to be overlooked. No matter how excellent the design of an aeroplane may be, its success depends on the efficiency and reliability of its engines. Indeed, the high performance of all types of British aircraft in the war is largely due to the technical advances which have been made in the design of high-power aero-engines. During the last few years power outputs and general efficiency have been greatly increased, and the technical lead which British aero-engines have long held remains unchecked.

An outstanding example is the "Hercules" engine, which is the latest of the range of "Bristol" sleeve valve air-cooled engines. The first successful sleeve valve aero-engine in the world was a "Bristol" product and was perfected and introduced after many years of intensive research. Since then development has never ceased and new and more powerful engines have been brought into production. The "Hercules" is the largest capacity and most powerful British aero-engine at present in large series production. It is now being used in the twin-engined Bristol "Beaufighter," the four-engined Short "Stirling," in certain big flying boats and in several of our newer two and four-engined heavy bombers.

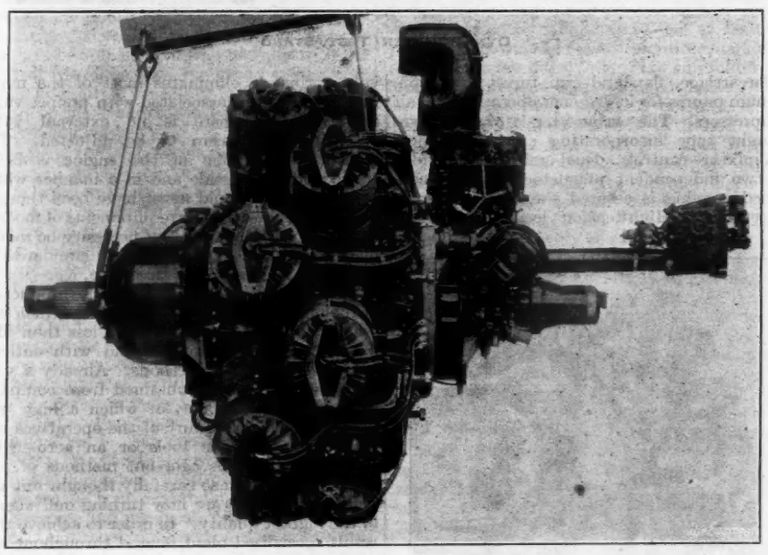


MASTER AND CONNECTING RODS

The "Hercules III" is a fourteen-cylinder double-bank air-cooled radial type engine, operating on the Bristol single sleeve valve principle. A two-speed supercharger is fitted in order to give optimum performance near the ground and at very high altitudes. The engine is intended to be used in conjunction with a controllable-pitch airscrew. The following are its principal features:—

Take-off power	1400 B.H.P.
Climbing power—	
Low-speed supercharger	1170 B.H.P. at 2500ft.
High-speed supercharger... ...	1090 B.H.P. at 14,500ft.
Maximum power for level flight—	
Low-speed supercharger	1425 B.H.P. at 1500ft.
High-speed supercharger... ...	1270 B.H.P. at 15,000ft.
Cylinder bore	5¾in.
Stroke	6¼in.
Cubic capacity	2360 cub. in.
Overall diameter	52in.
Airscrew reduction gear ratio ...	0·44 : 1
Weight	1850 lb.

The crank case is made up of three principal parts machined from aluminium alloy forgings and joined together at the centre lines of the two banks of cylinders. The cylinders, each of which is secured to the crank case by twelve studs, are staggered so that those in the rear bank are situated opposite the spaces between those in the front bank. The cylinder barrels are provided with close-pitched cooling fins and are machined from aluminium alloy forgings. A special type of cast Y-alloy cylinder head is used. Inside the cylinder barrels are the special alloy steel cylinder sleeves, which are operated by a crank arrangement driven from the crank-



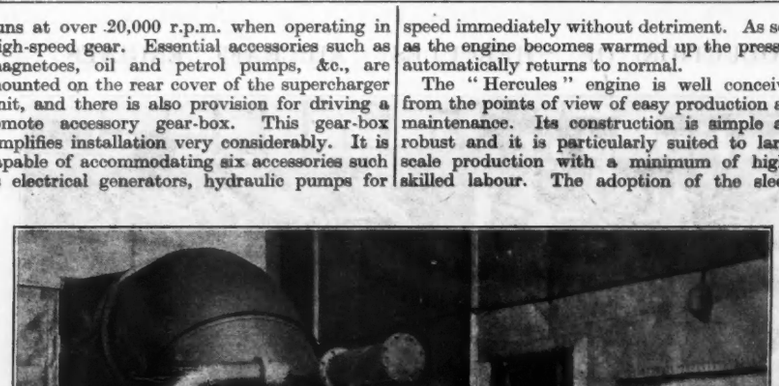
FULLY ASSEMBLED ENGINE

shaft through a system of spur gears. The pistons are machined from aluminium alloy drop stampings and have flat crowns. Three gas rings and two scraper rings are fitted to each.

The alloy steel crankshaft is of the built-up type, in accordance with standard Bristol practice, and is supported in three main roller bearings. The connecting-rods are of the master and articulated pattern with "H" section shanks.

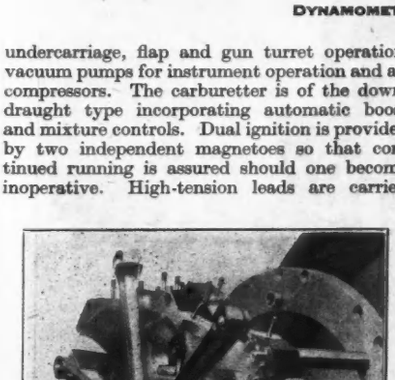
The two-speed supercharger unit is mounted at the rear of the crank case and is driven through hydraulically operated clutches from a torsion shaft splined into the rear of the crankshaft. The supercharger is of the gear-driven centrifugal type, which was first put into quantity production by the Bristol Company. The supercharger impeller of the double-shrouded type, is made of aluminium alloy and

runs at over 20,000 r.p.m. when operating in high-speed gear. Essential accessories such as magnetoes, oil and petrol pumps, &c., are mounted on the rear cover of the supercharger unit, and there is also provision for driving a remote accessory gear-box. This gear-box simplifies installation very considerably. It is capable of accommodating six accessories such as electrical generators, hydraulic pumps for



DYNAMOMETER TEST STAND

undercarriage, flap and gun turret operation, vacuum pumps for instrument operation and air compressors. The carburetter is of the down-draught type incorporating automatic boost and mixture controls. Dual ignition is provided by two independent magnetoes so that continued running is assured should one become inoperative. High-tension leads are carried



CRANKSHAFT ASSEMBLY

in screened harness to eliminate radio interference.

The engine drives a constant-speed airscrew through a reduction gear of the bevel epicyclic type at rather less than half crankshaft speed. Lubrication is effected by means of a pressure feed at 80 lb. per square inch, but a device is fitted whereby this pressure can be increased to 200 lb. per square inch for starting so that the engine can be opened up to full take-off speed immediately without detriment. As soon as the engine becomes warmed up the pressure automatically returns to normal.

The "Hercules" engine is well conceived from the points of view of easy production and maintenance. Its construction is simple and robust and it is particularly suited to large-scale production with a minimum of highly skilled labour. The adoption of the sleeve valve principle eliminates most of the maintenance problems associated with poppet valve engines, since there is no external valve operating mechanism to be adjusted. The quantity production of the engine is being carried out on a scale and in a manner which before the war would never have been thought possible for the exacting requirements of modern aero-engines, which must of necessity be manufactured to the very highest standards of materials, accuracy, workmanship, &c.

The shadow factory devoted to the production of the engine is an entirely new one, which was built up with a nucleus staff of less than fifty from the parent company and with entirely new machinery and methods. Already a very large output is being obtained from comparatively unskilled labour, of which a high proportion is female. Many of the operatives had never seen machine tools or an aero-engine until a few months ago, but methods of production have been so carefully thought out and studied that they are now turning out engines of the highest quality. In order to achieve that result specialised plant is used throughout and very rigid and complete systems of inspection and control are employed at every stage, from the incoming material to the testing of the finished engines on dynamometers in specially silenced test houses.

The Newcomen Society

OWING to delay in transmission, the address of the retiring President, Colonel C. E. Davies, Secretary of the A.S.M.E., did not arrive in time to be read at the coming-of-age meeting of the Newcomen Society on November 12th. Copies have now reached this country, and below we reprint those portions which refer specifically to the growth of the Society in America and Canada.

"WHAT'S PAST IS PROLOGUE"

The growth of interest in the United States came from the enthusiasm of Dr. L. F. Loree, one of four original members, a warm admirer of the Science Museum at South Kensington and a close friend of Dr. Dickinson, the Honorary Secretary and Treasurer of the new Society. In 1924, at his invitation, Dr. Dickinson came to the United States to participate in the centenary celebration of the Delaware and Hudson Company. Dr. Dickinson held several conferences with interested individuals which launched the activity. In January of 1925 there were thirty-seven members in the United States and Dr. Charles Penrose had been serving for a year as a member of the Council. The first meeting was held at the Engineers' Club in New York on April 22nd, 1925. At this meeting, as at subsequent meetings during his life, the influence of Dr. Loree exerted a profound effect on the programme. His historical perspective and realistic practicality made him a strong leader in the work of the Newcomen Society. He had the distinction of having presented the first paper from the United States to the "Transactions."

The first American pilgrimage was held in the summer of 1926, when a group of twelve visited the area between Providence and Boston, where the early textile and ironworking industries of the country originated.

It is impossible in this address to recite all of the activities of the Newcomen Society in the United States since its inception in 1925. Two should be mentioned. In 1926 a tablet was placed on the grave of Josiah Hornblower, the British engineer, who in 1753 brought the first "fire" engine to the United States. The engine, of the Newcomen type, was used to pump out a copper mine in Northern New Jersey. The Society participated in an international celebration of the bicentenary of the birth of James Watt in 1936, one interesting feature of which was the broadcast from the Science Museum in South Kensington and the companion broadcast from New York.

Twenty-two members from the United States have contributed twenty-seven papers to the "Transactions" of the Society published in London. Dr. Loree had the honour of contributing four, Mr. Greville Bathe and Dr. Geo. Orrok two each. All the papers are splendid contributions to the industrial history of the United States.

About seventy-five papers presented before the meetings in the United States have been published in pamphlet form and distributed to the members in the United States from funds received outside the dues of the members. A complete list of these papers accompanies this paper. A study of this list reveals the wide historical interest of the members in the United States. The early Colonial ventures into industry and transportation receive a large amount of attention, as does the more recent story of industrial development told by men who were responsible for these developments or whose forbears were pioneers in their creation. While a few of the addresses deal with current industrial problems, the combination forms a rich historical literature of which the Newcomen Society may well be proud. The Engineering Societies Library in New York and the library of the Franklin Institute of Philadelphia are depositories for these important papers.

The best way of explaining what the Newcomen Society in the United States is to-day is to review the programme for the past twelve months. Early in October of 1940 the Adirondack Pilgrimage was held under the auspices of the Eastern New York Committee. The members visited the site of some of the locks and a part of the Erie Canal built in 1825 and journeyed through an area rich in Colonial history as well as of great scenic beauty. The address on the canal was given by Dr. William Hotchkiss, President of Rensselaer Polytechnic Institute. Later, in October, there was a luncheon in Philadelphia in honour of Dr. Conrad Newton Lauer, President of the Philadelphia gasworks, who presented an address on "Philadelphia in 1840." As Philadelphia in 1840 was a shipbuilding centre, it was fitting that the Honourable Lewis Compton, Assistant Secretary of the U.S. Navy, accompanied by high-ranking naval officers, was present.

November saw a meeting at Chicago, where Fowler McCormick, grandson of the pioneer, Cyrus McCormick, traced the most interesting developments of farm machines. Again, in November, at New York, the fascinating story of the pioneers in Tennessee was related by Dr. Ernest Stockton, President of Cumberland University. In December the Alabama Committee met at the University of Alabama and after an inspection of its libraries and museums presented a model of the Newcomen engine to the University. In New York, also in December, Robert W. Wolcott, president of the Lukens Steel Company, told the fascinating story of Rebecca Lukens, who in 1825, at the age of thirty, shouldered the complete responsibility and management of an iron rolling mill. In January, again in New York, the history of the Chicago, Burlington and Quincy Railroad was given in an interesting address by Dr. Richard O. Overton. In February the Right Reverend Frank W. Sterrett, Bishop of Bethlehem and Chaplain of the Newcomen Society in the United States, presented his philosophical thoughts upon the life and work of the engineer in the advance of civilisation. Dr. Thomas Jefferson Wertenbaker, Professor of History at Princeton University, appraised the industrial growth and achievement of the United States from its inception in 1687 at the meeting in New York in March. Also in March, the Alabama Committee honoured the Alabama Polytechnic Institute and presented a Newcomen engine to that institution. Two meetings were held in New York in April, one the seventeenth annual dinner, at which Rear-Admiral George H. Rock, U.S.N. (retired), former Chief of the Corps of Naval Construction, reviewed the development, to which he had made substantial contributions, of increased safety in the design and construction of ships. St. George's Day gave opportunity for an international gathering addressed by Hon. H. J. Cody, President of the University of Toronto, whose address was entitled "Historical Background of Applied Science." In May, in New York, Charles Francis Adams, former Secretary of the Navy of the United States, was the guest of honour. The fall season was opened by a meeting in West Virginia, addressed by Dr. Raymond Geist, of the United States Department of State, who reviewed the current situation in Continental Europe. In October the Lancaster-York Committee spent a day visiting points of historical interest and enjoyed an address by Dr. Herbert H. Beck on "Colonial Life in Lancaster County."

The high light of progress in the United States and a contribution toward a better understanding of joint problems of Great Britain and the United States was the dinner in Washington on October 23rd in honour of Lord Halifax, British Ambassador to the United States. Lord Halifax's sincerity and confidence made a deep impression on the 200 members of the Newcomen Society who had gathered from distant points to meet him and hear his message.

As this address is written fifty members of the Newcomen Society are returning to their homes from a pilgrimage to Maine, where, under the auspices of the New England Committee, they visited a modern shipyard.

This brief recital of twelve months' activity of the Newcomen Society cannot do justice to the interest and enthusiasm shown at the meetings. It does reveal a vigour and strength which promises well for the future of the Society.

From the four members listed in the first volume of "Transactions," the membership in the United States has increased to nearly 2000. There are thirty-six committees of the Society in the United States and one in Canada. Nine of these committees were responsible for the seventeen meetings held during the previous calendar year. The members of the Newcomen Society are men of leadership in industry, transportation, finance and education, and a substantial number of them are interested in the history of engineering and industry. The group is under the leadership of Dr. Charles Penrose, whose energy is unbounded and who is devoting a large amount of his time to furthering its work and to whom great credit is due for its present status.

"What's Past is Prologue." What will the future drama unfold? The organisation now in being has great power for usefulness in developing the purposes of the Society. What are the problems that face this group in the United States and what should be its future course?

An obvious, but very important, step should be the development of much closer co-operation between the groups of the Newcomen Society in Great Britain and the United States. It is a matter of great satisfaction that Dr. Dickinson was able to spend several months in the United States in 1938. It was a great pleasure to have entertained President Pendred in 1930. Other than that, there has been all too little contact between the members in both countries. Some means must be found to bring this about, and it is possible that in the large area of contact now being developed between leaders in all fields of industry and science in both countries substantial progress can be made during this current period of great stress.. To that end, therefore, I enjoin the officers and active leaders on both sides of the Atlantic.

For the group in the United States some suggestions seem to be in order. The United States is large, distances between its centres of industry are great. Outside of a relatively small section of the country its technological history is in the very recent past. The field of usefulness now being developed, but that may be more intensively developed, is the safeguarding of this recent history by a study of its growth and the selection of important records and objects for safe keeping for the benefit of the future.

Its numbers may be expanded, for there are many in the United States who might well be brought into the ranks to make fundamental contributions to the Society's purpose. It should not be over-expanded, however, and the number of its members might well be determined as the number which, organised in local committees for each of the principal industrial areas, will be sufficient to deal usefully with the historical development in each area. The present committee structure still leaves a few gaps to be filled and toward which efforts are already being made.

But what of the larger usefulness of the Newcomen Society? A British writer in *Foreign Affairs* points out that the Declaration of the Atlantic, signed by the Prime Minister of the United Kingdom and the President of the United States, is more than a restatement of democratic faith and carries, implicit in every line, a proclamation that hope for the world's future lies in the continued collaboration of the Oceanic Commonwealth of Free Nations. He goes further to point out that at the present time the unity of effort in the common cause is overshadowing smaller differences of opinion; but if co-operation is to continue in periods of lesser stress and colder emotion, a long process of re-education in each country is necessary in which two things will be essential. The first is the need for a high ideal of complete unity and the second is understanding that sentiment of friendship and pledges of loyalty are not enough. We must not pretend that there are and can be no differences between Great Britain and the United States, but we should see the conditions coming, be prepared to understand them and find means of relieving them without disturbance to the main current of friendship. In this view I join and express the hopes that as we face the present together and as we work into the problems of a post-emergency, the Newcomen Society, by fostering closer understanding and co-operation between thoughtful leaders in both nations, may perform a useful purpose.

In dedicating the library at Hyde Park, where his papers are to be safeguarded, President Roosevelt pointed out that the dedication of a library is in itself an act of faith. For a nation to house the records of the past in buildings, he said that we must believe in three things—the past, the future and, above all, "in the capacity of (its) people so to learn from the past that they can gain in judgment for the creation of the future." By the same token, the Newcomen Society is in itself an evidence of faith. Its work is the analysis of the past for the benefit of the future. To that end it may make its contribution to the future well-being of the free peoples of the world.

Wire Ropes and Cordage

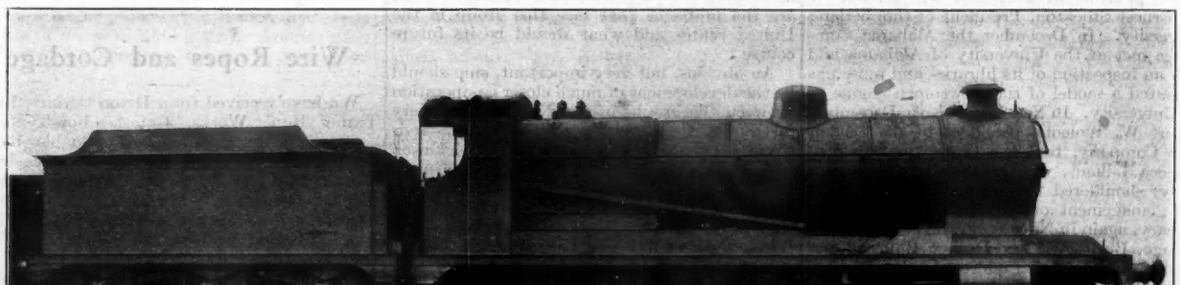
WE have received from Dixon Corbitt, Ltd., Teams Rope Works, Gateshead-on-Tyne, a copy of an interesting and valuable book, "Wire Ropes and Cordage," which has been written by Capt. D. E. Grant, the company's managing director. The firm has a history extending back over a century. In 1838 Mr. Lewis Gordon, while a student on the Continent, became interested in the hoisting of ore from mines and observed that the chains and hemp ropes used for the purpose restricted the depth from which the ore could be raised. On returning to England he consulted Charles Liddell and Robert Stirling Newall, and as an outcome a firm, R. S. Newall and Co., was established in 1840 for the purpose of making wire ropes. Gordon's active association with the firm could not, we imagine, have been prolonged much beyond its very early days, because in 1840 he was appointed by Queen Victoria to fill the newly established Chair of Engineering at Glasgow University, an office in which he was succeeded in a few years' time by Macquhorn Rankine. The company began its operations by manufacturing "Newall's Patent Untwisted Wire Rope," the form of rope now universally known as "ordinary lay." Later, in conjunction with John Lang, one of its managers, it developed the form known to this day as "Lang's lay." In its early days it turned its attention to the manufacture of submarine cables and on being entrusted with the production of a portion of the first Transatlantic cable it established a branch works at Birkenhead. The other portion of the cable was completed by Elliott and Glass at Bristol. As is well known, the cable broke after functioning only for a few days. A long law suit followed, during which it was alleged that the cable broke because a nail had been driven into it or alternatively because one half of it had been made with a right-hand and the other with a left-hand helix, so that the one part acted against and untwisted the other. Between 1850 and 1860 the company made many other submarine cables.

Simultaneously with the founding of R. S. Newall and Co. another wire rope and cable company, Dixon and Corbitt, was established on the opposite bank of the narrow Teams River. In 1887 the two undertakings were amalgamated and since that date the firm, now known as Dixon Corbitt, Ltd., has confined most of its attention to the manufacture of wire ropes and hemp cordage. To it is owing the introduction of the first plant to be established in the North-East of England for the spinning of Manila fibres and for manufacturing Manila hemp ropes. It has also been responsible for starting the manufacture of harvester twine from Russian hemp and of sisal binder twine.

After tracing the history of the firm the book presents in a very interesting and valuable manner particulars and data concerning various patterns of wire rope and cordage, including notes on such matters as the lubrication of wire ropes, splicing, sizes of drums, sheaves and pulleys, the attachment of sockets and the safe use and care of ropes. The book should prove of high value to all users of ropes and cordage. It has been prepared in a very attractive style, to which its numerous and clear illustrations contribute a large part.

LIMESTONE GRINDING PLANTS.—In order to assist agriculture, the Ministry of Agriculture and Fisheries has under consideration plans for opening limestone grinding plants. Provided such a plant is run efficiently and its output directed to agriculture, the Government will provide 60 per cent. of the cost. Where no one will undertake such an assisted enterprise the Government is prepared to provide 100 per cent. of the cost. In that case the plant belongs to the Government.

L.N.E.R. 2-8-0 FREIGHT LOCOMOTIVE FOR OVERSEAS SERVICE



Freight Locomotives for Overseas Service

IT has already been announced that ninety-two powerful L.N.E.R. 2–8–0 freight locomotives are to be sent overseas to aid our Russian Allies. The original locomotives of this design were built by the old Great Central Railway at its Gorton works in 1911, and by 1912 contracts had been placed with various British locomotive builders to produce these engines as the standard freight locomotive for traffic in the South Yorkshire coalfields. During the war of 1914–18 they were chosen because of their high tractive effort, their extreme simplicity of design, and their accessibility as the standard freight locomotive for service with the British Forces overseas. For this service various detail modifications were made to suit the Continental stock they were to haul. Westinghouse pumps and piping were fitted, and many of the engines incorporated steel fire-boxes in their construction. Several hundred were built by the British locomotive industry.

On the cessation of hostilities they were returned to this country and found their way on to various British railways, with the result that in the early 1920's they were to be seen at work almost throughout the length and breadth of the British Isles. Some also found a place on the railways of China and Australia. The majority, however, were returned to the old Great Central Railway, and over the twenty intervening years between then and the opening of the present war, they have proved themselves to be one of the most efficient locomotives in the country from a traffic point of view. They are also one of the cheapest and most easily maintained locomotives of the present L.N.E.R. freight locomotive stock. The parallel boiler barrel and the straightforward Belpaire box make it one of the simplest of boilers to construct, whilst the outside cylinders leave the inside of the frame free for accessibility to the direct drive Stephenson link motion.

When the call of the present war came, this type of engine was again chosen as the most suitable of available stock for service with the British Forces, and ninety-two have been reconditioned and have already been sent overseas. They now all have copper fire-boxes and have gone out fitted with steam brakes. Their general characteristics are as follows :—

Cylinders	21in. dia. by 26in. stroke
Heating surface—	
Fire-box	154 sq. feet
Tubes	1349 ,,
Total evaporative...	1503 ,,
Superheater	242 ,,
Combined heating surface	1745 ,,
Grate area, sq. feet	26·24
Tractive effort	31,326 lb.

Sixty Years Ago

SCIENCE AND ENGINEERING

MANY engineers—but not all—would agree to-day with the views which we expressed in a leading article on science and engineering which appeared in our issue of December 2nd, 1881. What, we asked, had science done for engineering ? We sought to show that pure science had so far always followed the engineer instead of preceding him, and that natural philosophy owed more to the engineer than the engineer owed to it. Those who had materially improved the world were for the most part men whose information was very limited, even judged by the standard of the day in which they lived and quite insignificant as compared with modern standards. George Stephenson, we said, could not have passed a modern examination for a county surveyorship to save his life. James Watt's natural philosophy was of the crudest type. Trevithick the elder knew little. Rennie never even heard of elementary truths taught nowadays to every schoolboy and girl. Richard Roberts, Arkwright, Cartright and Crompton were all, so far as science was concerned, ignorant men, and the same could be said of Maudslay and John Penn. It was next to impossible to name any man who was a pioneer engineer and did great things who was also a man of science. Science always followed instead of leading. She could compile and develop, but not originate, and there was a growing belief that a highly scientific training was fatal to mental development. Not one single real improvement had been made in the steam engine by men of pure science or by the mathematician. Rankine did nothing for it ; Carnot's theorem had not even modified its construction. Bessemer, when he invented the process of blowing air through iron, was not a man of science. He was despised by scientific men until his process was made a success, not by any aid from them, but by David Mushet's common sense and the use of spiegeleisen. The evidence was overwhelming that a scientific training had not been essential to the success of an engineer and that science had invented nothing and discovered nothing of importance to him. . . . There was more to the same purpose, but it is probable that we were writing more with the object of being perverse than of being strictly accurate. George Stephenson's scientific attainments may have been small, but he fully recognised his deficiency in that respect and took good care to send his son Robert to Edinburgh University to obtain the benefits of a scientific education. Watt's natural philosophy cannot justly be described as having been of the crudest type. He was in direct contact with the science professors of Glasgow University and at an early date fully appreciated the practical significance of Black's discovery of the latent heat of steam. And so on we might go, but perhaps the best reply to our arguments of sixty years ago is to be found on the page immediately facing that on which we printed them. We there published the third of a series of articles by Walter R. Browne, M.A., on "The Foundations of Mechanics," exalting and expounding the contributions made to natural philosophy by Newton, Rankine, Maxwell, Clausius and many others.

Supplies to Russia

THE Information Department of the Government of India states that one more link with Russia is being established with the organisation of a regular supply route from India *viâ* Baluchistan and East Persia. Already a trial journey, delivering much-needed supplies of jute, has been made and has yielded much valuable information concerning the barren and particularly waterless 760 miles of country between Nokkundi, the terminus of the Indian Railway in Baluchistan, and Meshed, in North-Eastern Persia. A second experimental trip with a consignment of shellac is to be made, after which a regular service will be speedily evolved. A Persian Auxiliary Transport Service, supervised by an officer with a long experience of similar problems in Waziristan, has been formed. It consists of a large number of lorries from India with Indian civilian drivers, along with Indian clerical staff, and fitters for breakdown and repair service. The Persian Government is co-operating in the effort by waiving certain customs formalities and assisting in protecting the route. Thousands of tons of war materials and raw commodities from the great democracies are being sent to Russia *viâ* every possible point of delivery on the Caspian seaboard and in the Caucasus. At ports on the Persian Gulf, such as Basra, Khorramshahr, Ahwaz, Bandar, Shahpur and Bushire, consignments of goods are now arriving from Great Britain, the Empire and America in ships of almost every nationality. A Russian agency called "Iransovtrans" takes delivery of the goods at a series of points in Northern Persia. The railway transport will be increased by the arrival of rolling stock, locomotives and operating staff now on their way from India, England, Australia and Hong Kong. Port facilities are being developed by Indian firms of engineers and by the end of November it had been possible to increase by about four times the maximum number of trains. Basra, once the back door of the Near East, has now become the front door for Turkey and Russia. Supplies arriving at that port are sent forward both by rail and road transport, and we learn that the United Kingdom Commercial Corporation has already provided more lorries for road transport than can be immediately used and has contracted for a sufficient number of lorries to handle any volume of traffic likely to be handled.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer

Iron and Steel in the United States

The production of pig iron is at a high rate in the United States. The number of furnaces in operation was given in November as 214, and it was stated that stocks of coal were then sufficient to meet for thirty-one days the requirements of the steel works. All pig iron needs have been met, in many cases by deliveries arranged by the Control. In the Chicago district two new blast-furnaces are to be erected by the Government and leased to a private company. Part of the production will be used to relieve the existing shortage of scrap for the steel works. The capacity of the two furnaces will be 900,000 tons per annum. It is estimated that the capacity of the United States pig iron industry is 56,838,300 tons per annum from 213 furnaces. Additional capacity is planned amounting to 9,672,000 tons for 1942–43, of which sixteen furnaces with a capacity of 6,319,000 tons are already under construction. Five Bessemer converters are to be built for the production of 2,612,000 tons of synthetic scrap. The United States steel industry is operating at 96·6 per cent. of capacity. During the third quarter of the year the finishing departments of the United States Steel Corporation produced in excess of their rated capacity, whilst the shipments of finished steel during October were the highest for forty years and amounted to 1,851,279 tons. The total capacity of the American steel industry has been estimated at 86,144,900 tons. There is a continued and increasing scarcity of scrap, which has resulted in a certain number of open-hearth furnaces being laid idle. For the first time ir five months a furnace in the Youngstown district has been shut down for this reason. Reserve stocks of scrap in all parts of the country are being drawn upon.

The Pig Iron Market

The demand for foundry iron is well maintained, except in the high-phosphoric qualities. There is not more than a moderate request for these, since the light castings industry is poorly employed and likely to remain so for the duration of the war. There are good stocks at the blast-furnaces and most consumers have built up stocks during the summer with the approval of the Control for use in case of an emergency. The heavy engineering and jobbing foundries, generally speaking, are well employed and the heavy foundries in particular have big order books. These establishments benefit from the expansion in the requirements of the armaments and munition makers and the machine tool makers. The light foundries on the North-East Coast are drawing their supplies from the Midlands, but this does not involve them in higher costs, as the delivery charges are included in the price which is fixed by the Control. The heavy basic iron requirements of the steel works have led to the concentration of most of the blast-furnaces on the North-East Coast and other parts of the country upon this class of iron, and no Cleveland foundry iron is now being produced. Supplies of basic iron are, in fact, good and the steel works are receiving their full requirements. The tightness in the hematite department is noticeable, but the firms employed upon this work are well looked after by the Control. When it was decided that the imports of iron and steel scrap and pig iron from the United States had to be drastically reduced, Great Britain was thrown upon its own resources for hematite. The Iron and Steel Control, however, had foreseen this position and had previously managed to accumulate considerable stocks. It is from these sources that the country's needs for hematite will have to be met in the future.

The North-East Coast and Yorkshire

The position of the steel works on the North-East Coast is fairly comfortable, since there are good supplies of raw materials and the demand, whilst insistent, is not so pressing in some departments as earlier in the year. Production, too, has reached, and is maintained at, a high level. The works rolling heavy structural steel are finding only a moderate demand and in a number of cases could do with more work. Lately there has been a slight improvement in the demand for heavy joists and sections and there are indications that these may increase. Many constructional engineers are actively engaged upon fabricating structural steel for the shipyards. Business in plates continues upon a heavy scale and the shipbuilders, boilermakers and the wagon builders are consuming heavy tonnages of thicker plates. Probably the demand from these sources will continue for a long period. Sheets are required by the Services, and as a consequence a fair amount of business is reaching the mills, which for a time were somewhat short of orders. The demand for special and alloy steels for the armaments manufacturers continues to expand and the production of this class of steel is on a heavy scale. Even so, it does not much more than meet the needs of the consuming works. Active conditions rule in the Yorkshire steel industry and there, as in other steel-producing areas, one of the most noticeable features of the position is the increasing demand for alloy steels. The production of these has been increased considerably, but further plant extensions are being made to meet the country's requirements. The production of basic steel is on a large scale, but the demand for structural descriptions has fallen off to an extent that does not call for any great exertion on the part of the manufacturers to meet. Busy conditions prevail in the tool steel department and production is increasing as the demand grows.

Scotland and the North

The Scottish steel works are fully employed and the raw materials position is satisfactory. The scrap position has improved a great deal during the past few months and some of the works are holding considerable stocks. Business in finished steel is maintained on a heavy scale, but there is only a moderate demand for heavy structural steel. At the same time, most of the Scottish constructional engineers appear fairly well employed and some of them are actively engaged in fabricating materials for the shipyards. There is a strong demand for plates and sections, which are being absorbed by the shipyards in large quantities and required to an increasing degree by the tank makers. The medium-size plates seem largely in request, but the demand is considerable for most thicknesses. The sheet makers are assured of active employment for the remainder of the year, but there is a tendency for new business to slacken in some cases. Contracts are being worked off more quickly than new business is coming forward. The Scottish steel makers are busy and boilermakers, power plant makers and marine engineers are working to capacity and in some cases have had to turn down orders. The Lancashire market is active and big supplies of steel are passing to firms engaged upon Government work. There is a big demand for alloy steels, which seems to be increasing rather than the reverse. There is also a good inquiry for colliery steel. A vigorous demand exists for steel bars of practically all sizes. In some cases the works require rather long periods for delivery, but there is a considerable variation in this respect. Re-rollers are well employed and as they hold substantial stocks of billets are able to produce small steel bars and strip at a satisfactory rate.

The Midlands and South Wales

The demand for finished steel materials in the Midlands is on an impressive scale, although most of the works producing heavy joists and sections are experiencing a rather quiet time. The re-rollers, however, are getting plenty of orders for smaller sizes of structural steel, and as their position with regard to billet supplies is good they are producing on a heavy scale. Plate mills are working to capacity and although the demand seems principally for the thicker and the lighter sizes there is a fair business passing in plates of moderate thicknesses. Large tonnages pass regularly to the shipyards and tank makers, who are the largest consumers; but the boiler and wagon makers are also taking good quantities. An active business continues to pass in alloy and special steels from the armament manufacturers, and although the production of this class of steel has been expanded manufacturers' resources are being tested by the heavy call. Colliery steel of all descriptions is in demand, but makers have been able to keep consumers well supplied. A considerable volume of business is passing in steel bars, but the demand is spread somewhat unevenly over the industry and some of the mills are able to give better delivery than others. On the whole, however, the steel works appear to be keeping their deliveries well up to date. Business in sheets fluctuates, but the mills are comfortably placed and should remain busy for some months. There is a tendency, however, for completed contracts to be in excess of new business and an extension of the demand for this material would be welcomed. There are no new developments in the steel situation in South Wales and most of the works are fully employed upon priority orders. Delivery periods are fairly good and the outlook is satisfactory.

Copper and Tin

The copper position remains steady and, in spite of the extremely heavy demand, British firms engaged in the war effort receive their full supplies. The intensification of the production of munitions has resulted in the extension of factories, and it is anticipated that the demand for copper for war purposes will still further increase. In the United States there is some talk of shortage, but the position does not appear to be at all bad considering the enormous amount of copper which is being used by the American defence programme and in supplying the democratic Powers. If the position did get really tight it has been suggested that it would not be difficult for the United States authorities further to reduce supplies of copper for non-essential work. The United States, of course, can always obtain supplies from South America, subject to shipping space available. . . . The chief item of interest in the tin position is the meeting of the International Tin Committee, which was held on December 1st in London, when the question of the continuation of the tin control agreement, which expires on December 31st, 1941, was again considered. After the meeting it was officially announced that the Governments of Bolivia, the Belgian Congo, the Netherlands, East Indies, Nigeria and Malaya accepted the standard tonnages recommended by the Committee and agreed to the draft agreement proposed for the regulation of tin control for a further period of five years from January 1st, 1942. The Government of Thailand has not yet accepted either the form or the whole content of that draft, and it rejects the standard tonnages proposed. Alternative proposals have been made by them which the Committee is unable to recommend for acceptance. The Committee recommended to the Governments concerned that the control agreement drafted by the International Tin Committee and the standard tonnages proposed by them should be accepted, and that tin control should continue in accordance with that agreement, even if the Government of Thailand should finally be unable to accept the draft agreement and the standard tonnages the Committee propose. The Committee expressed the hope that the Government of Thailand would accept, prior to December 31st, 1941, or, if they were unable to do so, they would at a later date be in a position to rejoin the other Governments in continuing to exercise control on the terms which the International Tin Committee recommend, and which Governments, representing approximately 93 per cent. of the recent production of the present signatory countries, have already accepted. Should the Government of Thailand eventually decline to join in the system of control, the Committee have suggested certain alterations in the scheme to safeguard the position of the participating countries. On the assumption that the five Governments mentioned will accept the above recommendation, the Committee have fixed the quota for the period from January 1st to June 30th, 1942, at 105 per cent. of the new standard tonnages. This percentage corresponds closely to 130 per cent. of the present standard tonnages. The standard tonnages proposed in the new agreement are:—Belgian Congo, 20,178 tons; Bolivia, 46,768; Malaya, 95,474; N.E.I., 55,113; Nigeria, 15,367; Thailand, 18,500; total, 251,400. The Committee also recommended that the present buffer stock scheme, which would normally expire on December 31st, 1941, should be continued, with effect from January 1st, 1942, for the period of the main tin control scheme. If these recommendations are accepted by the Governments concerned, the agreements will be published as soon as possible.

Non-ferrous Metal Prices

The official statement of the London Metal Exchange for November shows slight increases in the average quotations amounting to 18s. 1d. for cash and 10s. 3d. for three months, compared with the October averages. The settlement average is 18s. 3d. higher than that for the previous month. The statement, which includes the official maximum prices for copper, lead, and spelter, is as follows:—

		£	s.	d.
Standard tin ...	Cash (mean)	£256	17	6
	Three months (mean)	£260	8	0
	Settlement	£256	17	9

The following prices for copper, lead, and spelter are the maximum prices fixed by the Controller of Non-ferrous Metals:—

	Delivered buyers' premises. £	s.	d.
Standard copper	—		
Electrolytic copper	62	0	0
Electrolytic wire bars	62	0	0
Best selected copper...	60	10	0
Lead, good soft pig (foreign)	25	0	0*
Spelter, G.O.B. (foreign)	25	15	0*

* Duty paid.

Notes and Memoranda

Rail and Road

MEXICO'S NEXT RAILWAY.—A commercial enterprise known as the Cia. Mercantile Industrial y Constructora is to provide 10,250,000 dollars for the construction of a 280-mile railway to connect the States of Oaxaca and Chiapas. A Government concession to build the line was secured some time ago.

NO CHANGE SINCE 1838.—The regulation thickness of a railway ticket dates from 1838, when they were introduced on the Manchester-Leeds Railway. Since then thickness of train tickets has remained standardised at one-thirty-second of an inch. Now the L.M.S.R. is reducing it to one-forty-second, and other railways are expected to follow suit. Last year alone the L.M.S.R. printed 250,000,000 tickets.

A LARGE-SCALE MODEL.—The Parks Committee of the city of York has granted permission to the York and District Society of Model Engineers to construct a model railway track in Rowntree Park for the Society's own use, on the understanding that the Corporation accepts no responsibility in the matter, and that any money which the Society may receive from charges for using the track be given to some approved charity.

SOUTH AFRICA MAKES LOCOMOTIVES.—Diesel engine-driven locomotives for underground and surface haulage are being made by Landsborough Findlay (S.A.) (Pty.), Ltd., at its works at Denver, Johannesburg. Locomotives ranging from a small 1½-ton unit for a special 50 cm. gauge for the Belgian Congo, to a heavy shunting locomotive of full standard gauge for surface duties, have been turned out from the works in the past year.

A NEW ZEALAND PROMOTION.—Mr. P. R. Angus, A.M. Mech. E., locomotive superintendent, New Zealand Government Railways, has been appointed chief mechanical engineer. Mr. Angus has been associated with the Railway Department ever since 1910. In 1918 he was appointed assistant locomotive engineer at the Auckland railway shops, and was later at Greymouth on the West Coast, and in 1924 at Wellington, where in 1926 he was appointed assistant chief mechanical engineer. He held this title until 1933, when the office of chief mechanical engineer, which had been vacant for some years, was abolished, and Mr. Angus became locomotive superintendent.

Air and Water

FROM WASHING MACHINES TO GUN SIGHTS.—An example of the way American engineering is being transformed is to be found in the fact that the U.S. Army has given the washing machine industry the job of producing 12,000,000 dollars' worth of 50-calibre machine gun mounts in factory space which is idle or soon to become idle, due to inability to get materials for normal operations. Three concerns have been selected to receive prime contracts, and these will divide up the work among the other thirty-one washing machine producers, in accordance with the amount of curtailment each faces. The Army contract represents the total immediate requirement of the military for machine gun mounts.

AMERICA MUST HAVE MORE ALUMINIUM.—To meet the increasing demand for aluminium for aeroplane construction, the U.S.A. Office of Production and other defence departments have entered into a contract with the Aluminum Company of America for the construction and operation of an alumina plant in Arkansas, with an annual capacity of 400 million pounds, and three aluminium smelting plants. Some 3000 million pounds of alumina annually is now considered necessary to produce 1400 million pounds of aluminium metal per year. The plants proposed will extend the useful reserves of bauxite in Arkansas almost threefold by bringing into use low-grade ores never previously considered of commercial value.

BRITISH AIRCRAFT INDUSTRY SCHOLARSHIPS.—Five scholarships in the aircraft industry have been awarded for 1941 in the fifth year of the scheme financed by the Society of British Aircraft Constructors and administered by the Royal Aeronautical Society. In addition, under an extension of the scheme, nine boys already employed in the industry have been picked out for special S.B.A.C. apprenticeships for training in works management, works production, and other branches of aircraft engineering. The scholarships are intended to attract to the higher ranks of the industry lads whose financial circumstances would make it impossible for them to take up an aircraft apprenticeship, as distinct from the ordinary trade apprenticeships.

Miscellanea

WASTE PAPER AND PAPER CONTROL.—In the week under review there has been further progress in the campaign to produce the 100,000 tons of waste paper so urgently needed for the wartime production of armaments. The Waste Paper Recovery Association has continued its programme in wide areas with good results. It is well to remember some of the articles which are badly needed in the production of munitions which can be produced from 1 ton of mixed waste paper, which may include cardboard boxes and cartons. They are:—1400 cylindrical shell containers, 9000 gun fuses, 11,000 interior components for mines, 350 mortar shell containers, 47,000 ·25-pounder shell cups, 47,000 boxes for 0·303 cartridges, 71,000 aero-engine dust covers, 36,000 cut-out targets, 3000 boxes for aero-cannon shells, 1000 cases for 2-pounder shells, and 140,000 washers. During the week the Ministry of Supply has issued an additional Order providing that the use by a paper or board maker of any waste paper or board as a material in any process of manufacture must be licensed under a Ministry of Supply Order.

BRITISH TIMKEN'S 21ST ANNIVERSARY.—At a luncheon in London, on Monday, Mr. E. J. Pascoe, managing director of British Timken, Ltd., in the absence of the chairman, Mr. M. B. W. Dewar, entertained some thirty members of the engineering and allied technical press. In the course of his speech he said that the occasion was the twenty-first anniversary of the firm's existence, and regretted that war conditions prevented the firm dealing with the occasion as, in better times, it would have done. In making appreciative remarks about the technical press, he said that he hoped before the Government decided on any further cuts in the supplies of paper, it would realise that the technical journals were not only necessary to the industries they served, but that they were an essential part of those industries. Mr. P. Marshall and others thanked Mr. Pascoe, and in the course of the remarks made a question was raised as to the wisdom of the policy which forced technical newspapers to send copies to overseas markets indifferently printed on poor-class paper to vie with similar journals from America and Germany, which were to-day being printed on the finest paper in the most elaborate style.

EFFICIENCY IN THE USE OF FUEL.—At the request of the Mines Department of the Government, a series of meetings has been arranged jointly by the Institutions of Civil, Mechanical, Mining, Electrical, Gas and Chemical Engineers, the Institute of Chemistry, the Iron and Steel Institute, the Society of Chemical Industry and the Institute of Fuel. The object of the meetings is to inaugurate an open discussion on the best ways and means of improving the efficient use of fuel and power in existing industrial plants under present conditions and to invite constructive suggestions. The meetings so far arranged are as follows:—Tuesday, December, 16th, at 2.30 p.m., in the Large Hall, College of Technology, Sackville Street, Manchester. The chair will be taken by Sir Robert Burrows, chairman of the Lancashire Associated Collieries, Ltd., the opener of the discussion being Dr. F. S. Sinnatt, D.Sc., F.R.S., the Director of Fuel Research and member of the Fuel Efficiency Committee of the Mines Department. Saturday, January 3rd, 1942, at 2.30 p.m., in the Large Theatre, H. H. Wills Laboratory, Royal Fort, Bristol. The chair will be taken by Sir Richard Redmayne, M.Sc., M. Inst. C.E., the opener of the discussion being Mr. J. G. Bennett, F. Inst. F., member of the Fuel Efficiency Committee of the Mines Department. Thursday, January 8th, 1942, at 2.30 p.m., in the Lecture Theatre of the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2. The chair will be taken by Sir Harold Hartley, F.R.S., Chairman of the Fuel Research Board, the opener of the discussion being Dr. E. S. Grumell, D.Sc., F. Inst. F., Chairman of the Fuel Efficiency Committee of the Mines Department.

Personal and Business

SIR H. A. WALKER has been elected chairman of W. B. Dick and Co., Ltd.

MR. W. CUTHBERT has been re-elected Chairman of the Clyde Navigation Trust.

COMMANDER SIR CHARLES CRAVEN has been re-elected Chairman of the Industrial Welfare Society.

MR. A. F. SIDGREAVES has been elected President of the Society of British Aircraft Constructors. Messrs. J. D. North and C. C. Walker have been elected Vice-Presidents.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Institute of Transport

Wednesday, Dec. 10th.—Connaught Rooms, Great Queen Street, W.C.2. Luncheon. Address by H. E. Clay. 1 for 1.15 p.m.

Saturday, Dec. 13th.—METROPOLITAN GRADUATES: Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. "Air Raid Precautions for Goods Road Transport," N. W. Sharratt. 2.15 p.m.

Institution of Automobile Engineers

Sunday, Dec. 14th.—LONDON GRADUATES: 12, Hobart Place, S.W.1. "Design Department," J. B. Perrett. 2.30 p.m.

Institution of Civil Engineers

Saturday, Dec. 6th.—YORKS. ASSOC.: Royal Victoria Station Hotel, Sheffield. "Mining Subsidence and Some Drainage Problems Arising Therefrom," H. J. Paul. 2.30 p.m.

Institution of Chemical Engineers

Tuesday, Dec. 9th.—Geological Society's Rooms, Burlington House, Piccadilly, W.1. "A New System of Double Filtration for Sewage and Certain Trade Waste Waters," A. Parker. 2.30 p.m.

Institution of Electrical Engineers

To-day, Dec. 5th.—METER AND INSTRUMENT SECTION: Savoy Place, Victoria Embankment, W.C.2. "Maximum Demand Metering—a Study of the Timing and Length of the Integration Period," D. J. Bolton. 4 p.m.

Saturday, Dec. 6th.—N. MIDLAND STUDENTS: Hotel Metropole, King Street, Leeds. "The Failure of the Technician in his *Rôle* as Citizen," D. S. Anderson. 2.30 p.m.

Monday, Dec. 8th.—N.E. CENTRE: Neville Hall, Newcastle-upon-Tyne. "Space Heating by Electrically Warmed Floors," R. Grierson. 6.15 p.m.

Tuesday, Dec. 9th.—SCOTTISH CENTRE: Royal Technical College, George Street, Glasgow, C.1. "Electricity Applied to Medicine," A. Bruce Maclean. 6 p.m.

Wednesday, Dec. 10th.—TRANSMISSION SECTION: Savoy Place, Victoria Embankment, W.C.2. "The Measurement of Lightning Voltages and Currents in Nigeria, 1938–39," F. R. Perry, G. H. Webster and P. W. Baguley. 5 p.m.

Institution of Engineers and Shipbuilders in Scotland

Tuesday, Dec. 16th.—39, Elmbank Crescent, Glasgow. "Influence of the Shape of Blade Sections on Singing of Propellers," G. Hughes. 6.30 p.m.

Institution of Mechanical Engineers

Tuesday, Dec. 9th.—Central Hall, Westminster, S.W.1. Conference on "Air Raid Precaution Measures and the Engineering Industry." 10.45 a.m.

Tuesday, Dec. 16th.—Storey's Gate, Westminster, S.W.1. Joint meeting with Inst. C.E. "Balance of Locomotive Reciprocating Parts," E. S. Cox; and "Hammer Blow in Locomotives: Can It Not be Abolished Altogether?" Sir H. N. Colam and J. D. Watson. 2.30 p.m.

Institution of Naval Architects

Wednesday, Dec. 10th.—Connaught Rooms, Great Queen Street, W.C.2. Luncheon. 12.45 for 1.15 p.m.

Institution of Production Engineers

Saturday, Dec. 6th.—COVENTRY SECTION: Canteen, Humber, Ltd., Coventry. "Surface Finish," G. Schlesinger. 4 p.m. LONDON GRADUATES: Inst. of Mechanical Engineers, Storey's Gate, Westminster, S.W.1. "Functions of the Technical and Publications Committee," W. C. Puckey. 3.30 p.m.

Friday, Dec. 12th.—N.E. SECTION: County Hotel, Newcastle-upon-Tyne. "Drop Forgings," A. Chilton. 6.15 p.m.

Friday, Dec. 12th.—Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W.1. "Sampling Inspection and Quality Control," B. P. Dudding. 3 p.m.

Institution of Structural Engineers

Saturday, Dec. 6th.—YORKS BRANCH: Hotel Metropole, Leeds. "Facings to Framed Structures," E. G. Warland. 2.30 p.m.

Junior Institution of Engineers

Saturday, Dec. 13th.—39, Victoria Street, S.W.1. Presentation of awards and induction of Lord Sempill as President. 2.30 p.m.

Manchester Association of Engineers

Saturday, Dec. 13th.—Engineers' Club, Albert Square, Manchester. "The Manufacture of Articles from Powdered Metals," W. D. Jones. 2.30 p.m.

Newcomen Society

Wednesday, Dec. 10th.—Watt Memorial Institute, York House, Great Charles Street, Birmingham. "History of Spring Balances," W. A. Benton; and "Origin and Manufacture of Wood Screws," H. W. Dickinson. 2.30 p.m.

North-East Coast Institution of Engineers and Shipbuilders

Friday, Dec. 12th.—Mining Institute, Newcastle-upon-Tyne. "Plastics and Engineering," A. Caress. 6 p.m.

Royal Society of Arts

Friday, Dec. 12th.—John Adam Street, Adelphi, W.C.2. "Facilities for the Technical Training of Artisans and Craftsmen in India," A. T. Weston. 1.45 p.m.